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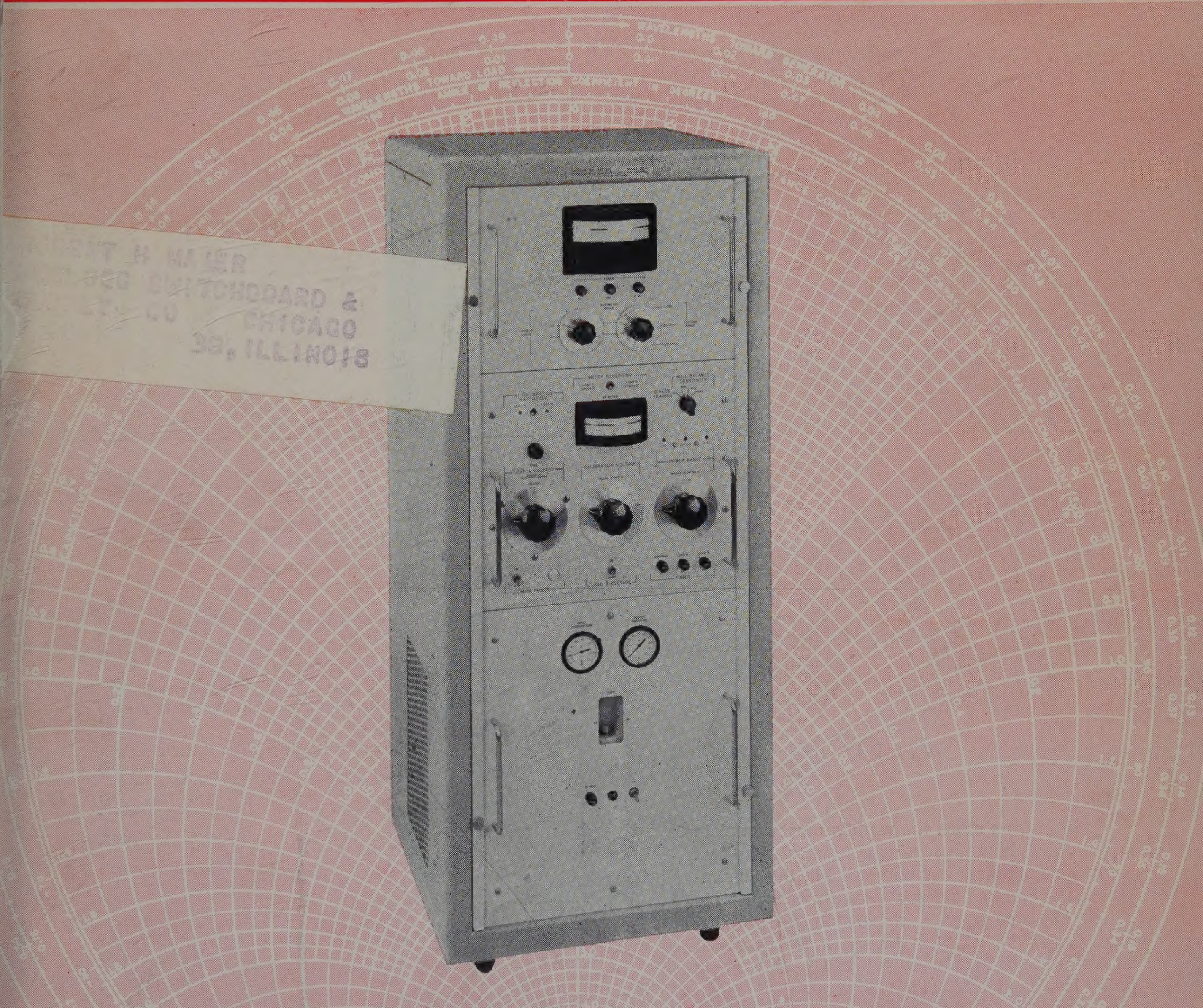
- Vinding — An Accurate Calorimeter for High Microwave Power
- Eakin & Rapuano — A Hybrid Duplexer
- Thomas — Fundamental Considerations of Microwave Video Diodes
- Shnitkin — Survey of Electronically Scanned Antennas — Part II

1127-1

he microwave journal



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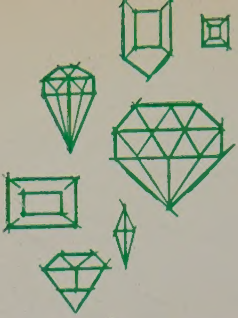
In This Issue . . .

SURVEY OF ELECTRONICALLY SCANNED ANTENNAS—CONCLUSION

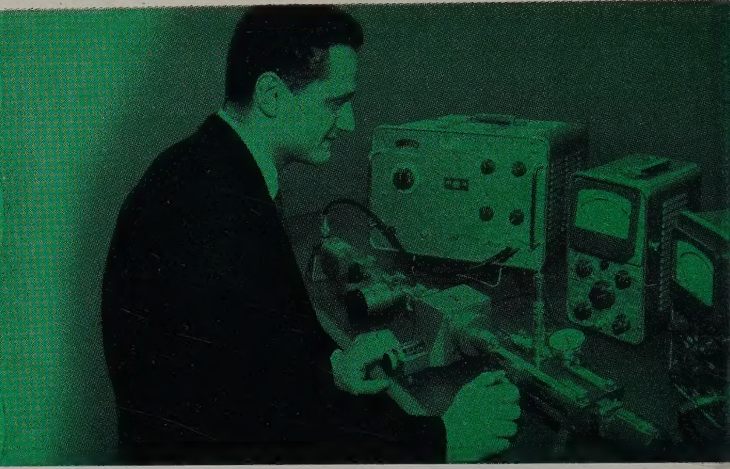


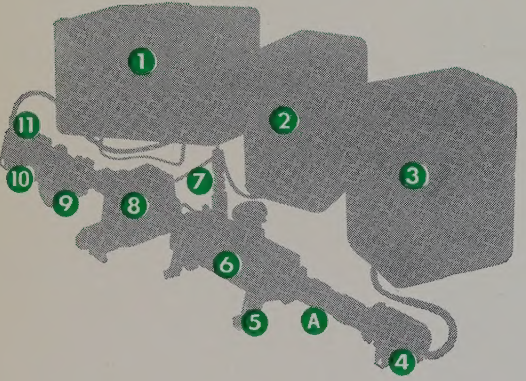
...one facet of FXR leadership in

MICROWAVE TEST EQUIPMENT

QUALITY CONTROLLED MICROWAVE TEST EQUIPMENT

The bench test set-up pictured here is used to check the calibration of the B831A Temperature Compensated Power Meter and its required accessory, the X218A Thermistor Head. This is but one of the many FXR Quality Control procedures applied before a unit qualifies for placement in stock.





FXR offers from stock the world's most complete line of microwave measuring equipment. The test equipment outlined and numbered in the illustration above can be used for X band measurements of VSWR, receiver sensitivity, attenuation, frequency, power level, coupling and impedance. Also shown in the outline is component Ⓐ undergoing power level comparison tests. Standard FXR instruments can be added to create sophisticated techniques for the measurement of other characteristics, including reflectometer measurements.

DELIVERY FROM STOCK

①	**X772A**	**SIGNAL SOURCE** Range: 7.0 to 11.0 KMC • Accuracy: ±1% • CW power output: 10 mw to 100 mw max. • Modulation: internal or external, pulse or square wave, external FM	**$1340.**
②	**B812A**	**STANDING WAVE AMPLIFIER** Range Selection: to 70 db in 6 decade steps • Meter: normal and expanded scales for VSWR and db	**$225.**
③	**B831A**	**TEMPERATURE COMPENSATED POWER METER** Range Selection: 6 direct reading ranges, 10μw to 3 mw full scale • Accuracy: ±5% min., (±1.7% RMS) • (FXR Series 218 Temp. Compensated Thermistor Heads a required accessory)	**$335.**
④	**X218A**	**TEMP. COMPENSATED THERMISTOR HEAD** Range: 8.2 to 12.4 KMC • For use with B831A or B832T Temperature Compensated Power Meter • Compensates for ambient temperature variations	**$145.**
⑤	**Z116A**	**UNIVERSAL CARRIAGE** For use with all FXR interchangeable precision slotted sections	**$150.**
⑥	**X115A**	**INTERCHANGEABLE PRECISION SLOTTED SECTION** Range: 8.2 to 12.4 KMC • Insertion length: 10⅜" • Waveguide type: RG-52/U • Flange type: UG-39/U	**$87.**
⑦	**B200A**	**TUNABLE PROBE** Fingertip tuning, dual controls • High stability	**$145.**
⑧	**X164A**	**DIRECT READING VARIABLE ATTENUATOR** Range: 8.2 to 12.4 KMC • Accuracy: 0.1 db or ±2% whichever is greater over full frequency range • Calibration to 50 db • VSWR: 1.15 max.	**$270.**
⑨	**X410B**	**DIRECT READING FREQUENCY METER** Range: 8.2 to 12.4 KMC • Accuracy: 0.08% absolute • Non-contacting tuning plunger • Can be used either as a reaction or transmission type meter	**$150.**
⑩	**X155A**	**DIRECT READING VARIABLE ATTENUATOR** Range: 8.2 to 12.4 KMC • Accuracy: ±1.5 db • Calibration: to 20 db • Excellent shielding, impedance match and stability	**$75.**
⑪	**X157A**	**FERRITE ISOLATOR** Range: 8.2 to 12.4 KMC • Isolation: 30 db min. • Insertion loss: 1 db max. • VSWR: 1.5 max.	**$195.**

DETAILED SPECIFICATIONS AVAILABLE

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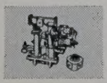

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AT NEW FRONTIERS...

SYSTEMS ENGINEERS

BSEE REQUIRED, MSEE DESIRED. MINIMUM OF FIVE YEARS EXPERIENCE. Needed immediately are men with Design and/or System Analysis experience in Radar, Data Processing, and Data Display systems. Large scale Systems experience is desired. Must be capable of conducting advanced system analysis of microwave systems for Navigation and Tracking. Experience in the design of low noise receivers is highly desirable.

DESIGN ENGINEERS

BSEE OR MSEE WITH TWO TO FIVE YEARS EXPERIENCE IN SUB-SYSTEM DESIGN AND ANALYSIS. Backgrounds in the design of UHF and Microwave Receiving equipment are required. Must be capable of directing a staff of specialists, and integrating development of sub-assemblies. Data processing experience is desirable.

MECHANICAL ENGINEERS

BSME WITH SIX TO NINE YEARS EXPERIENCE IN THE INTEGRATION OF MICROWAVE COMPONENTS, to large steerable antenna structures. Should have experience in antenna system design for missile or satellite applications. Will be concerned with the mechanical configuration of equipment designed to operate under extreme environmental conditions. Should have experience in quality testing and the writing of specifications, test procedures, and reports.

PHYSICIST

BS OR BA REQUIRED. ADVANCED DEGREE DESIRED. THREE TO SIX YEARS EXPERIENCE in Atmospheric Physics and Thermodynamic Analysis of Receiving Systems in their application to space programs. Knowledge of microwave emissivity and reflectivity of various material structures and configurations desired.

To arrange for a personal interview, please call: Mr. James O'Neill at OLympic 3-3300.

Ewen Knight CORPORATION

AT NEW FRONTIERS IN *Electronics*

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JANUARY, '61 vol.4 - no.1

the microwave journal

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Microwave Superregenerative Amplifiers

Frequency Independent Antennas — Several New and Undeveloped Ideas

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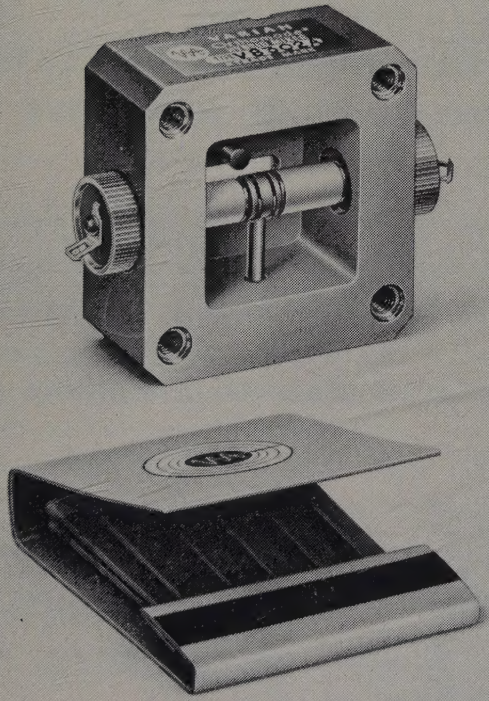
VARIAN ORTHOMODE® BALANCED MIXERS

X-Band C-Band S-Band



V-8302 A Orthomode® X-Band Balanced Mixer

Let's assume your particular design calls for the services of one of the smallest hybrid microwave mixers in the world. Must be rugged . . . perhaps you plan to fly it in a missile, or hook it into a back-pack radar system. Must be lightweight . . . something like ⅓ the weight of conventional magic-T or short-slot mixers. And must perform as well or better than big mixers.

Varian's new line of miniaturized Orthomode mixers beautifully meets these demands. Available in X, S, and C-bands, they're particularly suitable to airborne radar and missile applications where difficult packaging problems are always cropping up. And they include convenient lug terminals which permit crystal current monitoring without additional filtering.

FEATURES

- **Models Cover 3.95 To 10.8 kMc Range**
- **Low Noise Figure**
- **Unusually Small Size and Weight**
- **Wide Band Without Adjustment**
- **Withstand Extreme Environments**
- **Simple To Install and Use**

We'll be happy to provide additional technical data as to how this unique family of miniature Orthomode hybrid mixers can aid you. Just address Radiation Division.

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Circle Reader Service Card 1

MICROVIEWS
OF THE MONTH

41 ▶ AN ACCURATE CALORIMETER FOR HIGH MICROWAVE POWER

Jorgen P. Vinding

This paper describes a calorimetric arrangement for measuring RF powers between 30 and 1000 W with accuracy of one per cent or better and reading time of about one minute. The frequency range covered at present is dc-4 kMc with a coaxial RF termination and 5.8 - 12.4 kMc with waveguide terminations. Sources of errors are analyzed in detail and the evaluation of each error is presented.

47 ▶ A HYBRID DUPLEXER

Kenneth Eakin and Robert Rapuano

This report presents a method for duplexing higher power than is possible when using conventional radar duplexer techniques. The method takes advantage of the inherent properties of the plate tank circuits of a balanced multitube (klystron or triode) type of r-f amplifier. It provides the required nonreciprocal action necessary for duplexing when used in combination with microwave hybrid circuits.

50 ▶ FUNDAMENTAL CONSIDERATIONS OF MICROWAVE VIDEO DIODES

R. L. Thomas

This article discusses some fundamental considerations relating to the crystal diode as a low level detector in the microwave frequency spectrum. Aspects of the cartridge internal geometry low level diode parameters, and forward dc bias are described to indicate their possible effects on video diode performance. Comments on measurement level criteria in common usage and simple laboratory measurement techniques are included as items of related interest.

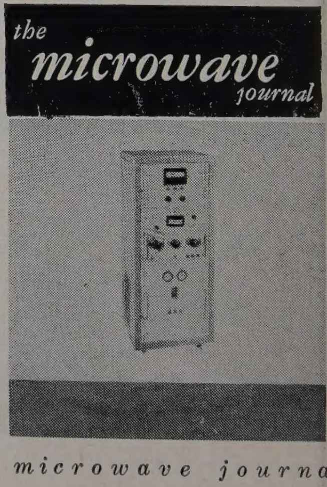
57 ▶ SURVEY OF ELECTRONICALLY SCANNED ANTENNAS — PART II

Harold Shnitkin

This is the second half of a paper discussing electronic antenna scanning techniques. This portion deals with the description of various mechanical and electronic phase shifters as well as several multi-beam techniques and beam switching methods. In particular the Hour Glass Scanner, Wullenweber array, multidirectional beam antenna, scanning by amplitude modulation, ferrite controlled radiating slots, and frequency conversion phasing are treated.

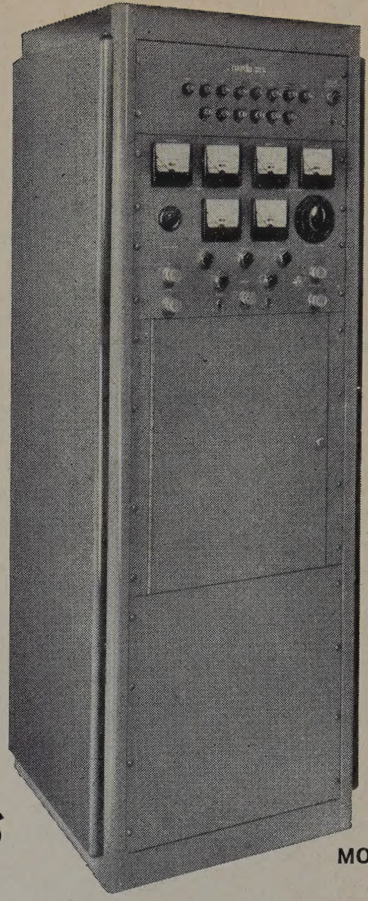
OUR COVER

A liquid flow calorimetric power measuring system produced by Philco's Sierra Electronic Corporation is shown on this month's cover. Employing balanced comparison measurement techniques, the system was developed to provide highly accurate measurements of radio frequency power throughout the range of 30-1000 watts. The system consists of the Model 290 Test Set console (housing calibration power sources, reference wattmeters and circulating heat exchanger) and the appropriate Dual Load assembly for the frequency involved. See page 41.



For greater versatility... longer life... increased reliability...

;pecify ARDA /icrowave Modulators



MODEL 10002
35 KV

e's a line of new Microwave Modulators, designed to operate aximum number of existing magnetrons, without any alterations the modulator. In addition, provision has also been made for :kly converting the unit to handle any new or uncommon pulse rowave tubes.

Models 10001 and 10002 are designed to handle high-power gnetrons with provision for internal mounting of the tube. Model)03 is designed for pulsing low-power magnetrons of the type now d in beacon transmitters and for low-power commercial pulse lications.

Since all units utilize silicon rectifiers and diodes, you can expect increased life and more reliable operation. At the same time, over-all size has been considerably reduced. Every Narda Microwave Modulator is complete with built-in safety provisions, built-in meters and viewing connectors for all principal parameters, a continuously variable repetition rate, and a standard pulse width of 1 microsecond (other widths available on special order) on Models 10001 and 10002; continuously variable on Model 10003.

The specifications below indicate those characteristics of the three new models which vary from each other. The listing of features indicates those features common to all models. For additional information, and a copy of our free catalog, write to us at Dept. MJ-9.

SPECIFICATIONS

Narda Aodel #	Maximum Peak Pulse Power	Pulse Width (Microseconds)	Maximum Duty Cycle # at Maximum Power	Size H x W x D
0001	18KV@20A	1*	0.001	38x22x18
0002	35KV@40A	1*	0.001	67x24x24
0003	4.5KV@2A	0.5-2.2†	0.002	8½x18x12

Other values of pulse width can be readily substituted.
Pulse width is continuously adjustable over given range.
Internal continuously variable trigger generator for adjusting repetition rate and duty cycle.

FEATURES

Built-in Meters:

High voltage power supply voltage
High voltage power supply current
Magnetron filament supply voltage
Magnetron filament supply current
Clipper average supply current*
*Models 10001 and 10002

Viewing Connectors (BNC):

Magnetron pulse voltage
Magnetron pulse current
Primary pulse voltage*
Thyratron pulse current*
PFN charging voltage*
*Models 10001 and 10002

Output sync pulses (BNC Connectors):

Positive
+ 50 v min. at 2 sec.
Negative
— 25 v min. at 2 sec.

Input sync (BNC Connectors):

Sine wave:
20 v RMS min.
Pulse:
20 v at .25 sec min.

the narda microwave corporation
HIGH POWER ELECTRONICS DIVISION
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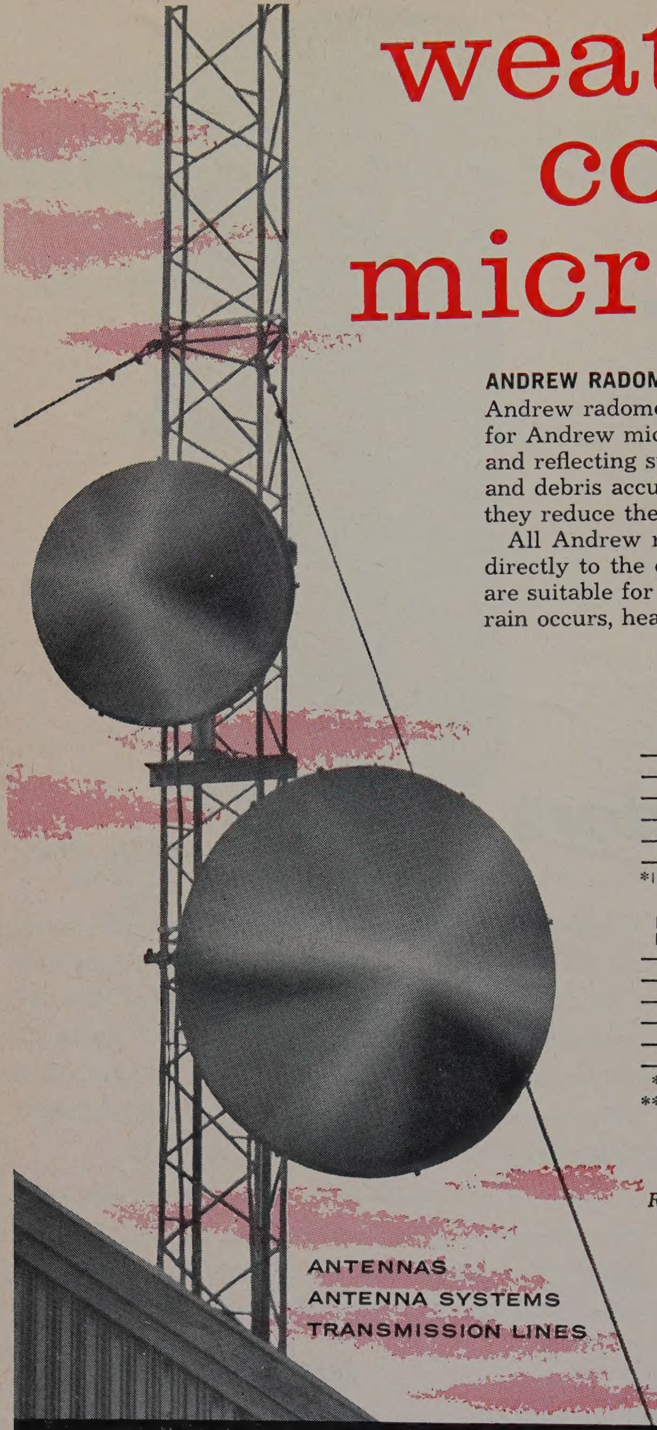
weather conditioned microwave



ANDREW RADOME EQUIPPED ANTENNAS DEFY ICE...SNOW...WIND

Andrew radomes provide excellent 2-way year-round protection for Andrew microwave antenna systems. First, they protect feed and reflecting surface against the attenuating effects of snow, ice and debris accumulation. Secondly, for tower mounted antennas they reduce the effects of wind thrust by 35%.

All Andrew radomes are lightweight and easy to install—clip directly to the dish rim of existing antennas. Unheated radomes are suitable for all but exceptional cases. In areas where freezing rain occurs, heated radomes can be provided.

SPECIFICATIONS

STANDARD RADOMES

Dia. Feet	Type No.	Attenuation @ 6 kmc. db	VSWR Contribution @ 6 kmc	Thrust at* 30 psf (Flats), lbs.
10	R10	0.4	0.02	1,990
8	R8	0.4	0.02	1,270
6	R6	0.4	0.02	714
4	R4	0.4	0.02	320
2	R2	0.4	0.02	75

*Including antenna

HEATED RADOMES

Dia. Feet	Type No.	Attenuation @ 6 kmc. db	VSWR Contribution @ 6 kmc.	Thrust at* 30 psf. (Flats), lbs.	Power** Reqmts.
10	HR10	0.7	0.02	1,990	3,400 watts
8	HR8	0.7	0.02	1,270	2,400 watts
6	HR6	0.7	0.02	714	1,200 watts
4	HR4	0.7	0.02	320	550 watts
2	HR2	0.7	0.02	75	150 watts

*Including antenna

**Power requirements for HR10 and HR8 are 3 wire single phase 60 cycle 220 volts.

Power requirements for HR6, HR4 and HR2 are single phase 60 cycle 115 v.

For further details on ANDREW Microwave Antennas, Radomes, Wave Guides write for new Andrew Catalog M.

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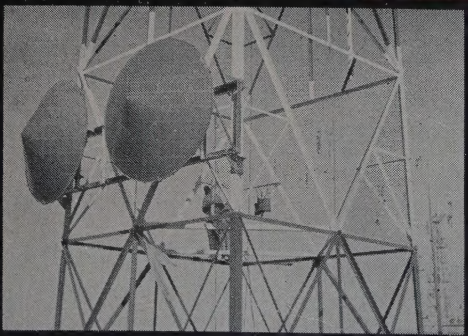
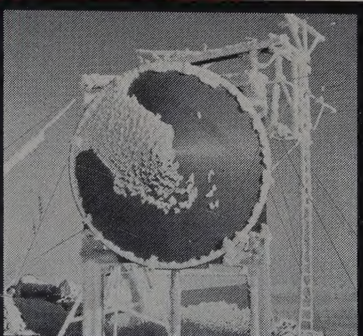


"We have paid particular attention to antennas during high wind conditions of gusts up to 40-60 m.p.h. It is very obvious that these radomes quite materially reduce the wind loading on the parabolas—due to their shape factor." *Washington State Patrol, Kennewick, Washington*



"We have had up to four inches of ice on the radome with practically no reduction of antenna effectiveness." *KLIX-AM-TV, The KLIX Corporation, Twin Falls, Idaho*

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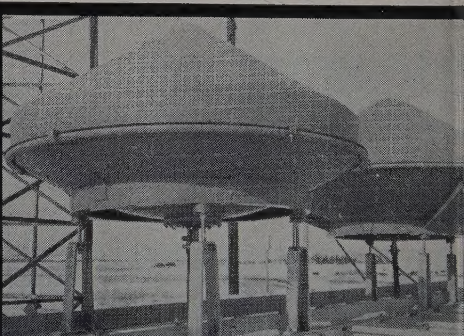

"Our field forces report that the radomes pr duce a signal loss of less than 1 db per antenn Several radomes were removed and antenn inspected following a heavy snow storm and snow or ice was found in the antennas." *Natu Gas Pipeline Company of America*

Circle Reader Service Card 4

Some specific examples of equipments listed in the new Granger Associates report: a coherent 500 kw VHF radar transmitter with pulse lengths of 100 microseconds; modulators for TWT, klystron, magnetron and negative grid tube applications —a typical unit providing 170 kv pulse at 180 amperes; pulsed and CW r-f sources covering the entire radar spectrum; a coherent rapid-stepping ionosphere radar transmitter and receiver; pulse distributed amplifiers—a typical unit covering 4 to 32 Mc at 100 kw; extremely stable, regulated d-c power supplies up to 20 kv at 2 amps with 20 millivolts ripple. These and other Granger Associates radar system components have evolved out of G/A's practical contributions in the field of experimental and developmental radar. The report shown below gives you complete specifications on these special purpose equipments. You will either want to use it immediately—or save it for ready reference. May we send you a copy—airmail?

This new report from Granger Associates gives you complete specifications on a broad range of special purpose equipment..... available now

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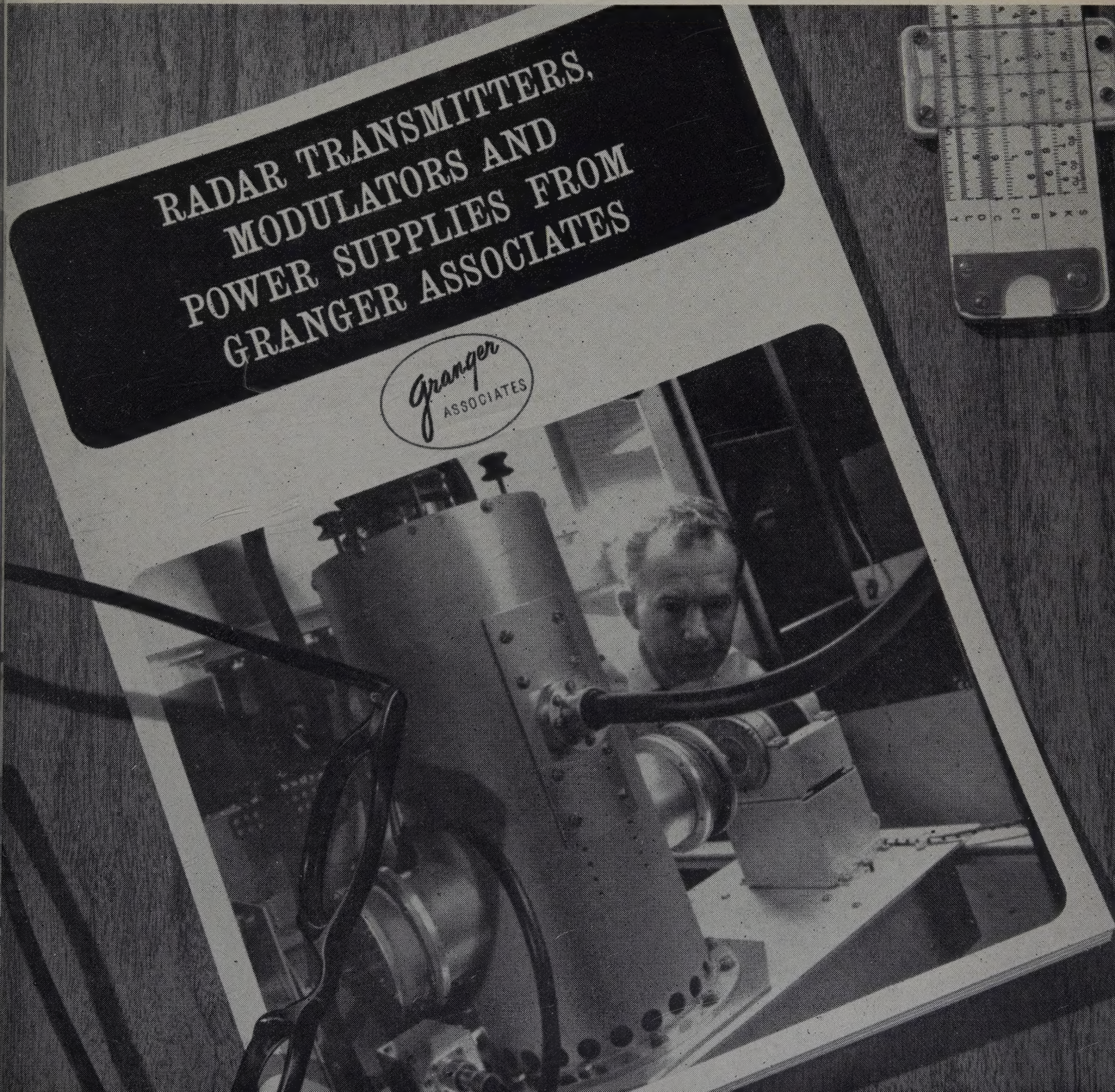


RADAR TRANSMITTERS, MODULATORS AND POWER SUPPLIES FROM GRANGER ASSOCIATES

THE PERILS OF SUB-CONTRACT WORK

Every once in a while the small microwave businessman comes up against a problem that is somewhat annoying.

The problem results from the fact that when a prime contractor asks a small sub-contractor to quote on a development program, there is no protection for the small sub-contractor, should the development program lead into production. It is not a new problem, nor is it an isolated problem. Many of us have learned to live with it, though somewhat begrudgingly.

An even more painful situation sometimes transpires when, in quoting, the prime contractor indicates a lack of funds for development and, furthermore, no assurance of the production order, should it materialize. If the sub-contractor wants the job, he usually bids it at a loss. Later when the production phase is let out on bid, it has better than an even chance of being awarded to an organization with little or no development talent, and hence much lower overhead than the original and by this time frustrated sub-contractor.

What can be done in a situation of this nature?

One possibility is patents. However, at the rate patents are processed, the idea is apt to be obsolete by the time any action is taken.

It seems unfortunate that there is no protection for the small sub-contractor in a situation of this nature.

What very often hurts the most occurs when, after months of diligent effort and financial loss, the development program is considered a success, only to have the production program—the cream—awarded to a production machine shop or its equivalent with no engineering or test capabilities. It is at a time like this when beachcombing has its greatest lure.

Occasionally the situation backfires, and the original sub-contractor is called back in to help rescue matters. But that does not happen often enough.

One dream solution that many have suggested is to so design the system, component, device, etc., such that it will disintegrate when being dismantled for close examination.

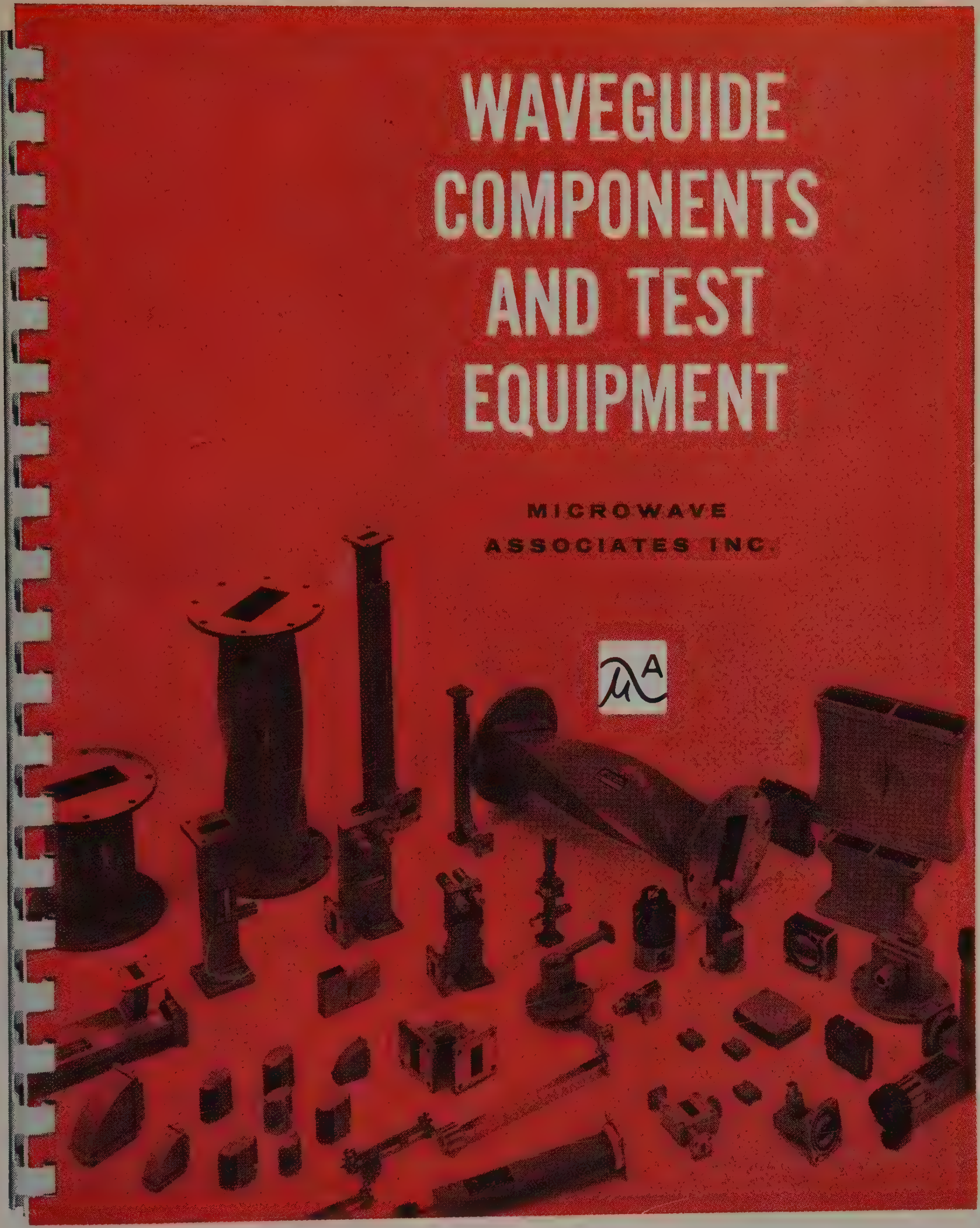
Many prime contractors try to help the situation by working with the sub-contractor, but their hands are tied legally, and the amount of service they can render is slight.

Although the situation described is typical, it has many variations. For example, a company designs a unique yet useful component, using its own funds. The component finds its way into a prototype system and later into the production program. At this point, the component is let out on bid to qualified (?) suppliers. Here again, a proprietary item developed, sometimes at great cost, can be copied, and the fruits of months of effort will be lost to a competitor.

These situations are facts of the microwave business, and one learns to live with them.

It seems strange that in a country with laws that protect the composer of "Hound Dog" for life plus 50 years, there is no way of at least giving the developer of ideas protection through the first production go-round.

Ted Saad



WAVEGUIDE COMPONENTS AND TEST EQUIPMENT

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Detailed specifications, application notes, photographs, and outline drawings on more than 750 Waveguide Components and Devices. Request your copy of this new 116 page catalog on your company letterhead today.

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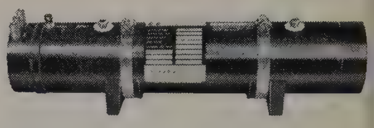
1 kw Hughes traveling wave tubes in S-Band

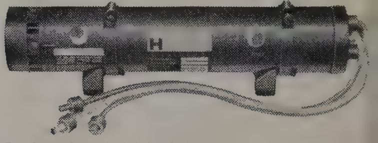
Now available in production quantities, these new and improved tubes offer you 1 kw of pulsed output power, with low power input, minimum heat generation and high reliability.

All these Hughes S-band tubes are lightweight, compact and ruggedly built to withstand the most severe environmental conditions—and provide long life. Each has been fully tested in the field.

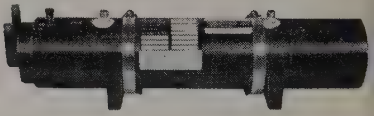
Three of these tubes provide full octave frequency ranges of 2.0 to 4.0 kmc and you have a choice of either ½ or 1% duty, in either ungridded or gridded versions, and with gains up to 37 db. All are permanent magnet periodically focused.



311H Gridded, 1 kw minimum peak power output, 1% duty, 36 db small signal gain @ 50 mw input. Weight: 13 lbs. Length: 17-7/16". Meets usual customer requirements of MIL-E-5400, Class I environmental tests.



312H Gridded 1 kw minimum peak power output, ½% duty, 36 db small signal gain @ 50 mw input. Weight: 11 lbs. Length: 15-3/8". Meets usual customer requirements of MIL-E-5400, Class I environmental tests.



304H Ungridded, 1 kw minimum peak power output, 1% duty, 37 db small signal gain @ 1 mw input. Weight: 12½ lbs. Length: 17-31/32". Meets usual customer requirements of MIL-E-5400, Class I environmental tests.

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engineer TO executive

. . . THE ENGINEER RISKS A GOOD DEAL WHEN HE ATTEMPTS THE SHIFT.”

M. C. PEASE
ASSOCIATE EDITOR
the microwave journal

One of the ever recurrent problems, both of the engi- r and of his employer is the wisdom of making the gineer into an executive. The need and the rewards great, but, if the attempt is made with the wrong ividual, the damage, both to him and to the organiza- n is often very extensive.

From the engineer's point of view, the change is npting in that it carries the promise of substantial vards. It is often said, more or less sincerely, that top ality engineering ability is as rare as executive talent, l should therefore be rewarded equally. This doctrine usually more of a wish than a fact. On the basis of nost any measure of success that is commonly used, re is a ceiling over the technical man that he can oid only by ceasing to be technical.

On the other hand, the engineer risks a good deal when attempts the shift. Many an excellent engineer has en turned into a third rate executive. The price of lure in terms of frustration, stagnation, and sheer loss accomplishment can be, and often is, truly a personal gedy.

From the standpoint of the employer, the problem is ually critical. He needs, often desperately, executives ho understand and can lead the engineering activity which the future life of his organization depends. is future depends not only on the quality of the sep- ate engineering programs being undertaken, but also the degree to which these programs are the separate rts of a whole which successfully anticipates the future eds of the organization. The engineering executive ust attract and inspire able engineers—and keep them spired—and must, simultaneously, direct their efforts to a general program that will provide the basis on hich the organization can meet and exploit its unknown ure opportunities.

The failure of the responsible executive to achieve ese ends is disastrous. The resources being used by his partment disappear into a bottomless "rathole." Even e successful projects do not seem to yield anything of lue to the company. The better engineers depart for e hinterlands. The residue disintegrate into turbulence d confusion. The decisions that govern the day-by-day tivities are not obviously wrong, but none of them are ght. The result is an agony of desperation and a residue failure that may take years to heal.

It is, therefore, a crucial problem for everyone to etermine whether or not a given engineer has it in him take on the executive role. Is he capable of the specific daption that the change will demand of him? Not can e do the job, but can he learn to do it?

It is an equally critical problem to recognize if the ganization will permit this growth. Not whether it ants to or not. Obviously it does. But the wish does not automatically make it so. In fact, it may do just the opposite. If the need is too great, the desperation it engenders will actually hinder the process of growth, or force it into falsity.

The engineer, faced with the opportunity to make the change, needs to be able to judge his own adaptability, and to judge also if the organization will be able to tolerate his inadequacy while he grows into that adaptation. The supervising executive needs to be able to decide to whom to offer the opportunity, and to be able also to recognize how much and in what ways the environment of the job will limit the development that is needed.

It is obvious that there is no prefabricated answer to these problems. If there were, they would be trivial. There are things that can be said, however. We can state, in at least broad terms, what is the nature of the problem and the reasons for failure. If such a statement gives us no magic formula for the avoidance of error, it may improve our understanding of the problem, and perhaps thereby may sharpen the institution on which we finally must depend.

One way of considering the problem is by an extrapolation of what the psychologists call "extension." In the strict sense of the term, the "extension" of a person is the physical limits of his sense of identity.

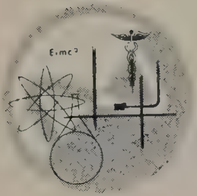
The phenomenon of extension is particularly noticeable when we do something we are well used to, and at which we have developed some skill. A competent driver, for example, is not consciously aware of the problem of driving the car. He does not need to think specifically of his own actions. Indeed, if he must, he is not a good driver.

A typist, a painter, a musician, a surgeon, anyone who uses a tool with skill and confidence has learned to extend his own sense of identity to include that tool. It is only when he has learned this trick that he is able to concentrate on the purpose of the work, and not on the details of performing it.

This is the classic concept of "extension." As such it is too narrow for our purpose here, but it can be easily enlarged.

Consider, for example, the conductor of an orchestra. The musicians within the orchestra are, in the classical sense, extended over their instruments. But what of the conductor? It is sometimes said that the conductor "plays" the orchestra. To him, the orchestra is, in its entirety, an instrument. It is not unreasonable to say that he is "extended" over the orchestra—that his personal sense of identity includes the entire group.

(Continued on page 14)



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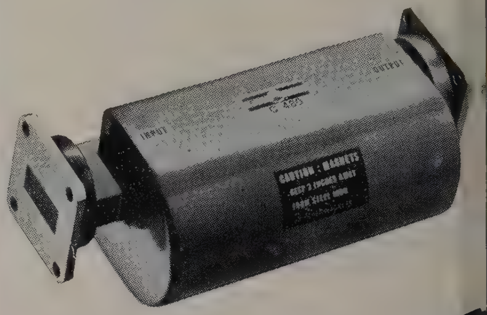

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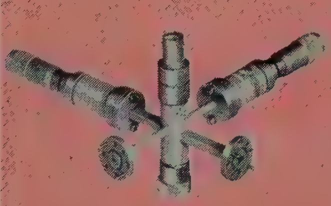

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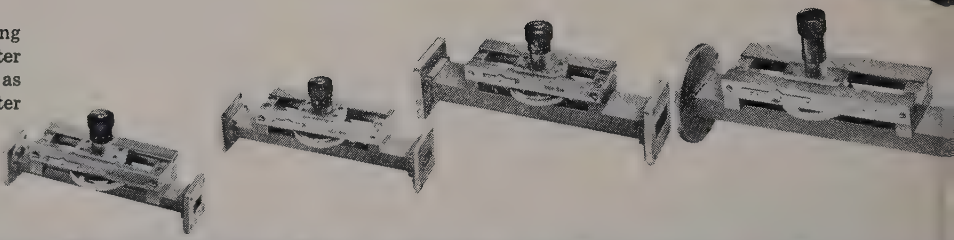

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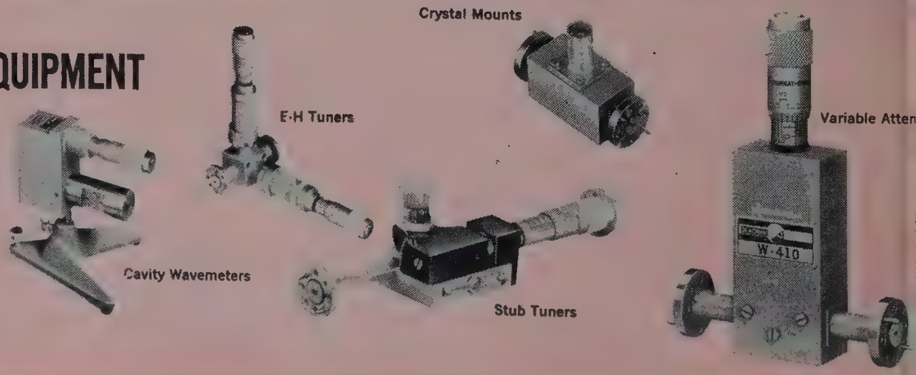

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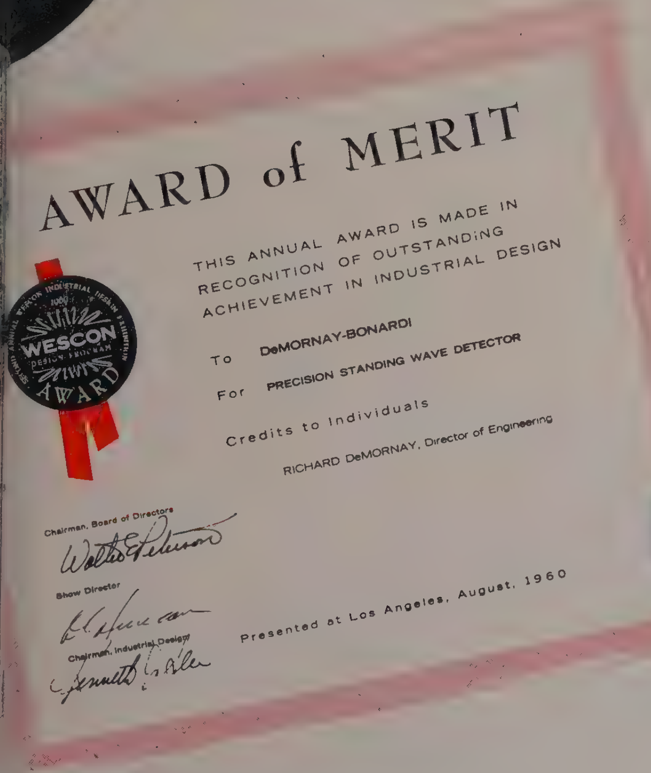

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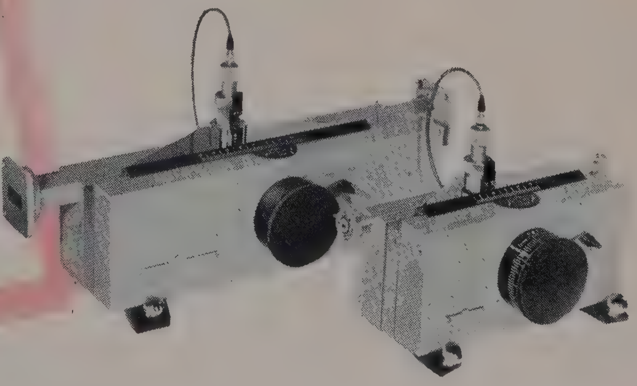

PEASE

(Continued from page 11)

If this use of the term be granted, then a whole new field of application is opened up. If we allow the term in situations where the range of extension includes other people as well as tools and instruments, then it becomes applicable to many of the situations of life.

This enlargement of the term from its classical sense is not simply a re-labelling. It is more than a semantic trick. It is meant to imply that the psychological mode of involvement is much the same, whatever the objects of the involvement. The same attitude is present, the same expanded sense of identity. While objectively, the two situations are very different, they are subjectively very similar.

We should note that extension does not imply perfect and automatic control. It is a matter of identification, not control. It is based, in fact, on a deep awareness of what are the limits of control, so that failure does not deny identification. If this is not so, then the extension is false. It will soon break down under the fact of failure, and the extension be withdrawn in the face of the necessity of determining, at each moment, just where the limits are. It is one of the prerequisites of extension that the individual be fully aware of just what are the limits of his control.

To interpret this concept in terms of the executive, we suggest that the competent executive is the one who can properly extend himself over the organization he heads. Given such an extension, he is then free to concentrate on the ultimate goals. He will have an intuitive understanding of his department, and of the people in it. He will know its capabilities, and how it may be develope into greater effectiveness.

If he does not make this extension he will very soo be in trouble. He will, for one thing, tend to accep things as he finds them. Having no feeling of identification, his department remains outside him. While consciously he has control, he has no feeling of being i control. It will probably not occur to him to make th demands that are necessary to develop the organizatio or even to prevent its disintegration. He is too "soft and, thereby, fails to meet the challenge.

Or else he compensates. Being aware, consciously c unconsciously, of his lack, he is too demanding. He i intolerant, unable to wait for the growth that he shoul nurture. He is tyranical in petty things, because he cann be sure what is petty and what is not: He is a "hard boss, but uselessly so. His toughness destroys, it do not build.

In either case there is failure. The failure of inactio or the failure of the wrong pressure applied at th wrong time.

The strong man, the one who can make the extensio and use it in an effective way, is the one who can wa until he has command of the situation. What needs to b done, he does. But only what needs to be done. He limi his actions to the minimum possible, in the confident expectation that extension will occur, and that, when does, then he will know the means of accomplishmen His fear is that the pressure of immediate crisis will forc him to actions whose consequences he is not yet able t foresee, and which may prejudice the future. He is stron enough to withhold action.

Men who know* prefer

The converse question then is whether the larger ganization can and will understand and tolerate the nstructive inaction that is the hallmark of the truly ong man. Will it see the difference between him and one who is inactive, not because he is not sure of the wer, but because he does not see the problem? And, n if this difference is understood, is the hierarchy ove him strong enough to let him do it? Or are they limited by fear that they must be able to point to asures taken? Can they, in the face of their problems, e with the inaction that potential strength implies?

There are many organizations that, at the lower levels least, cannot tolerate the man who is truly capable of veloping into the strong executive.

The difficulty, of course, is that the engineer turning ecutive does so generally at precisely these levels. In ing so, his lack of competence is enormous. It requires ong and maybe painful process of development. Painful him and dangerous to the company of which he is a rt. The very fact that his experience and training is as engineer makes the transition more difficult d dangerous.

The engineer is trained to extend over the interrelations the physical world. The device of abstraction is his ol. He is a fixer, not a doer. If the extension required the executive is analogous to that of the driver of an tomobile, then the engineer is analogous to the auto- otive mechanic. The driver, while manipulating through affic, must be aware of the limitations of his car as it is. e may have the fleeting thought that it is functioning a t raggedly and he had better have it tuned, but basically, is concerned with the outside situation and accepts e car specifically as it is.

The mechanic, on the other hand, while test driving the car, is much more concerned with it as it might be. And if the car-as-it-is is not identical with the car-as-it-might-be, he is trying to sense the possible and probable causes of this discrepancy.

One cannot be, at the same instant, both a good driver and a good mechanic. One often sees people who, though good drivers, are never good mechanics, or vice versa. The two states of mind are mutually exclusive in the instant. Often, because of personality and training, a given person is only capable of one, and is fundamentally incompetent in the other state.

The engineer is, in the same sense, dealing with abstractions. If he is a design or product engineer, these are abstractions of the things being built. He is seeking extension over what might be, so as to see what is wrong with what is.

The executive, on the other hand, must accept people as they are. It is of no service—and in fact, very much of a disservice—to think in terms of what would be if his people were only what they ought to be. He must have the feeling for the immediately possible that comes only from a deep understanding of what is.

There is, then, a very basic difference of viewpoint. The same individual may be intrinsically capable of both. Or he may not. Engineering competence demonstrates an ability to extend over abstraction, but it says nothing about the capability of extension over existing reality. It is for this reason that a top engineer may become a mediocre or worse executive.

(Continued on page 18)

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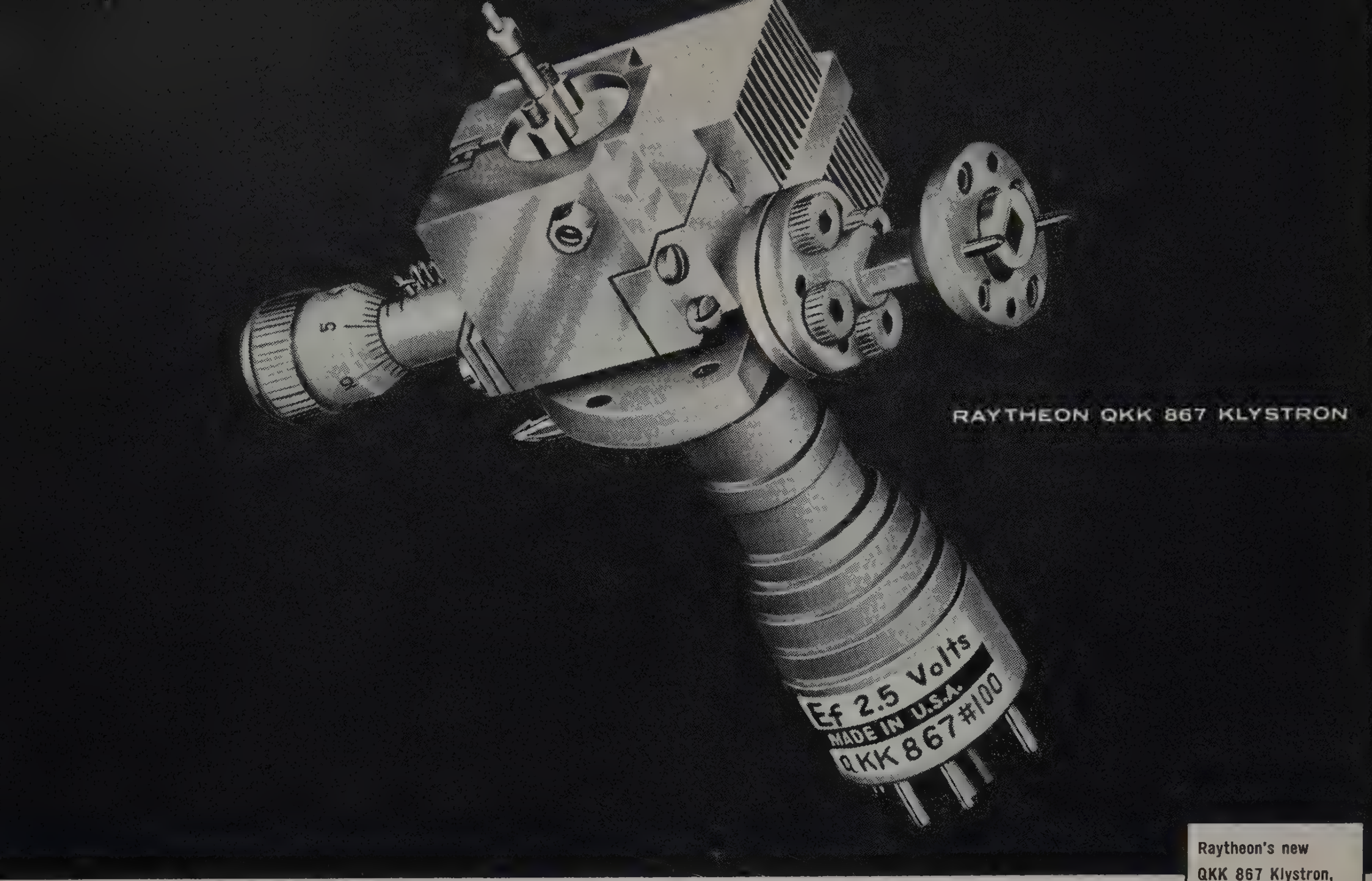

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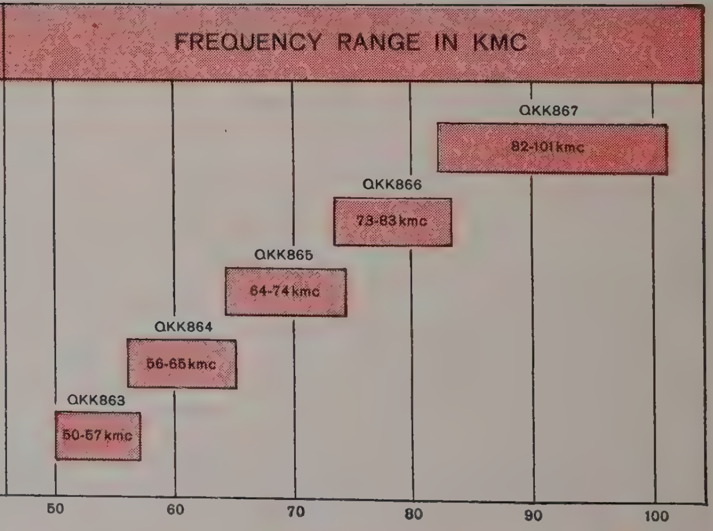

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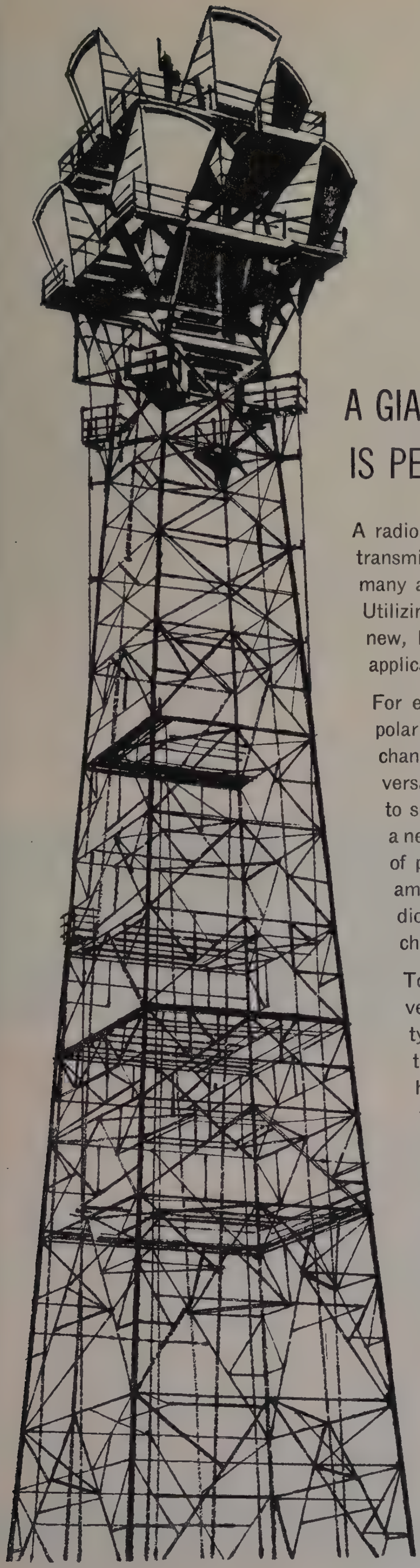

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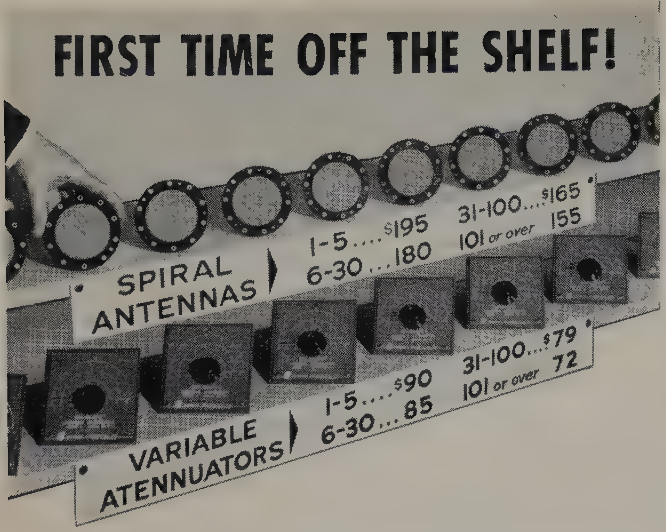

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PEASE

(Continued from page 15)

It is also for this reason that so many executives have so little understanding of engineering.

There is no magic formula for deciding who is able to make this change. Nor is it possible to tell when this change may occur. It is not even possible in the normal course of events to tell when, or to what extent, the change has occurred. There are clues, to be sure, but they can be misleading. That an engineer participates in various outside activities suggests an interest in, and capability for an as-is type of extension. But maybe he does so for a need that is not related to capability. And perhaps he is really functioning, even in these areas, on an as-might-be basis. Or if he does not participate in such things, it can be that he is so well related to what-is that he has no inner need to prove it.

The intricacy of the human mind is so great, and its possible modes of reaction so varied, that there is no objective test that cannot mislead. At least short of deep psychoanalysis. There is no infallible test.

There remains, then, only the delicate judgment of those who must make the decisions—the executive who offers or withholds the opportunity, and the engineer who accepts or rejects it. The clues of past behavior and of things accomplished may help, but the final judgment of each must be based on his own intuitive understanding. The quality of that judgment will be a direct consequence of their own abilities to extend over the as-is of the situation, and thereby, without rationalization to sense what growth is possible.

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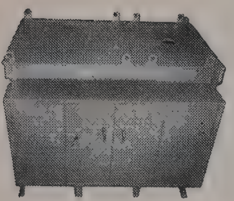

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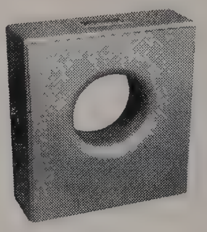

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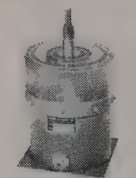

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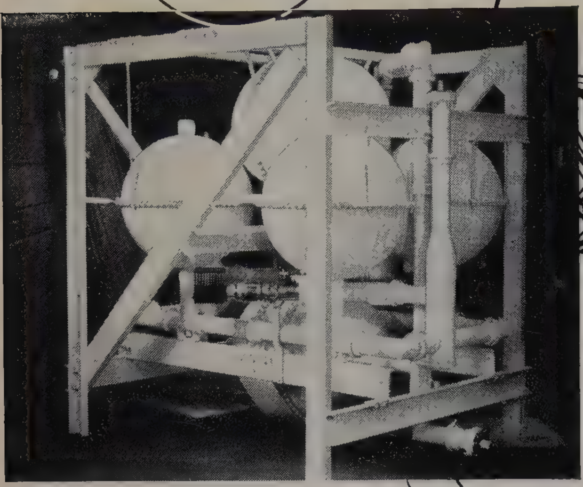

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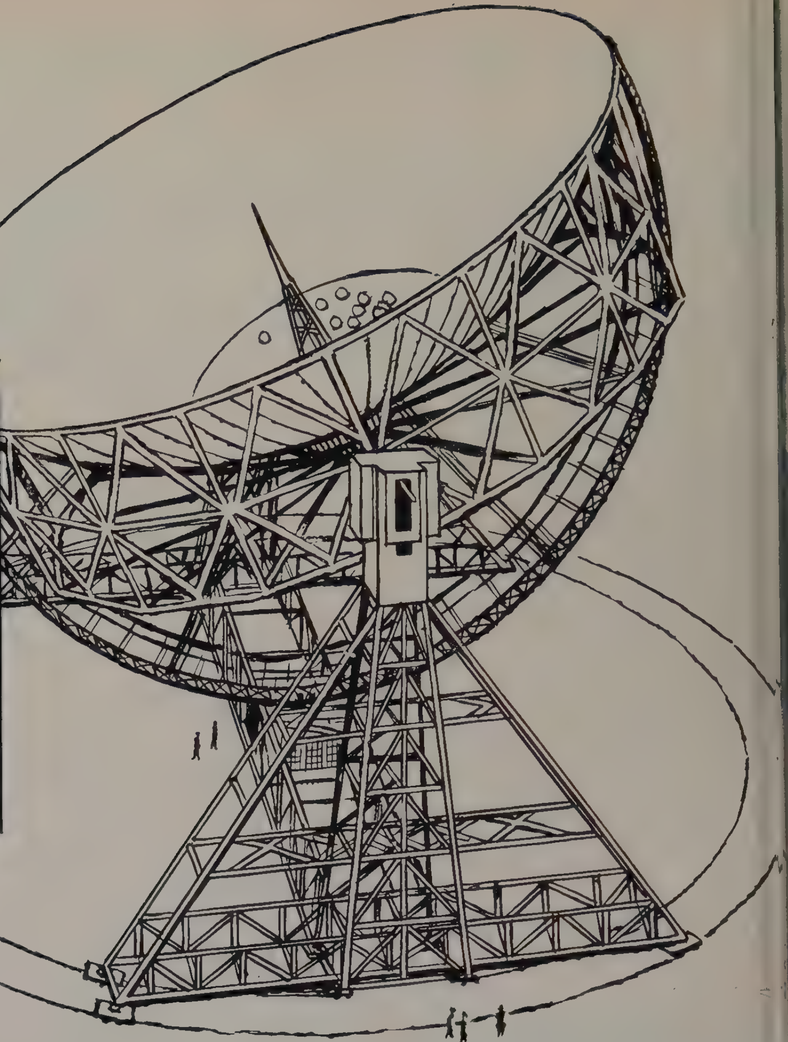

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Circle Reader Service Card 13

DR. KIYO TOMIYASU

Consulting Engineer

General Electric Co.

Schenectady, New York

By

WILLIAM HESTER

Las Vegas, Nevada, noted for its lavish gambling sinos is "home" to Kiyo Tomiyasu. "I was born in Las egas," he says, a statement not many can echo. His ther had come to Nevada for his health and started a nch in Las Vegas, in the heart of the desert.

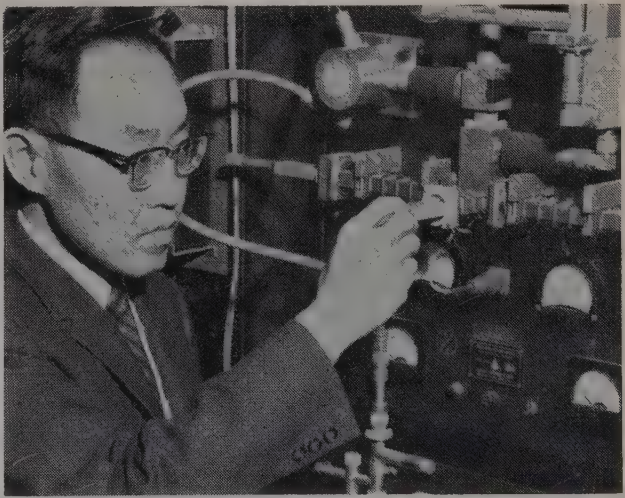
He reminisces about his childhood with obvious leasure. "When I was seven," he says, "my father let e drive our Model T, but I had an accident." His father en decided he was much too young to drive and ouldn't let him drive again for a whole year. But at ght he was handling the Model T by himself, riding all ver the desert.

Early in his school years Kiyo showed evidence of eative talent and engineering ability. He and his older rother were always tinkering and enjoyed the challenge f building new devices. They built a working hydrolectric plant and shortwave radio more to amaze their riends than because of any specific need for the comleted devices. But they did use the gadgets they built, lthough Kiyo admits there was more fun building than sing the equipment.

Kiyo received his EE degree from Cal Tech in 1940. hen he decided to see what the East coast was like so e went to Columbia University in New York for further tudy. He received his Master's degree there in 1941, pecializing in Communication Engineering. However, he winter was too much for him, so he returned to alifornia to begin his PhD work at Stanford. Unforunately, World War II started, and Kiyo headed back o Las Vegas, where he raised turkeys successfully on his lad's ranch until 1943. He volunteered for military duty out was turned down twice because of poor eyesight and lat feet. Then in 1944 he decided to head East again and ontinue his education at Harvard.

Kiyo entered Harvard University as a Gordon McKay Scholar to study for the doctorate. While working toward his PhD degree, he served first as a Teaching Fellow in applied physics and then as a Research Associate in Harvard's Electronics Research Laboratory. He studied under Professor R. W. P. King and obtained his doctorate in 1948. His thesis subject was, "Problems of Measurement on Two-Wire Lines with Application to Antenna Impedance."

While at Harvard, he met his wife, Eiko, at a Sunrise Easter Service. She was a student at Hunter College in New York at the time. Kiyo describes the event with mixed emotions. He awoke too late and missed the bus he had intended to take. The weather was cold and damp. "It was a miserable day," he says, but then adds hastily, "at first!"

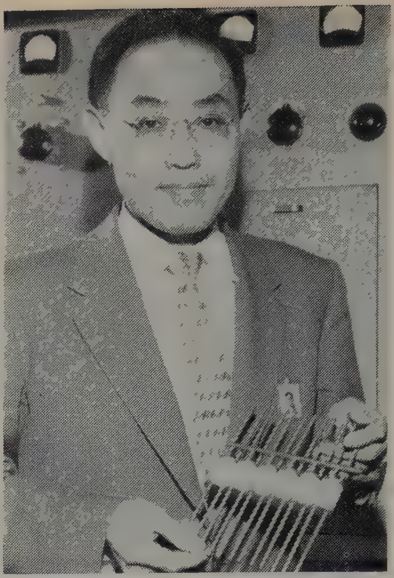


Dr. Tomiyasu tunes the pump cavity of 350-1200 Mc parametric amplifier designed by Mr. N. C. Gittinger of the General Electric General Engineering Laboratory.

He stayed on at Harvard as an instructor for another year after he became Dr. Tomiyasu and then went to work for Sperry Gyroscope in Long Island. In 1955, he went West again, to GE's Microwave Laboratory in Palo Alto, California. In the summer of 1960, he was transferred to GE, Schenectady, New York, where he is currently a consulting engineer.

Dr. Tomiyasu's experience since getting his degree covers many microwave fields. He has worked on transmission lines and antennas, an assortment of microwave components, and tubes. He is experienced with radar systems, passive radar, electronic countermeasures, and microwave spectroscopy. At least a dozen patents issued and more in process indicate that he is essentially component-oriented. Yet his more than thirty publications and technical talks show that he is equally at home with microwave techniques and microwave theory. His papers have appeared in the Journal of Applied Physics as well as in the Proceedings of I.R.E. and the PGMTT Transactions.

Kiyo's associates regard him as an excellent engineer who attacks a problem methodically and thoroughly. They indicate that in his engineering work, he always knows where he is, where he's been, and where he's going. True or not, the following story is told about him. While he was at Sperry, some of his fellow-engineers were amazed at his preciseness at work and wondered whether he was just as systematic in other matters. As a test, one of them slipped a quarter into Kiyo's pocket without him knowing it. Kiyo did know or thought he knew exactly how much change he had at all times, and when he found the extra twenty-five cents, it bothered him. He worried about it for two days, but couldn't figure it out, and finally threw the quarter away to keep the record straight.

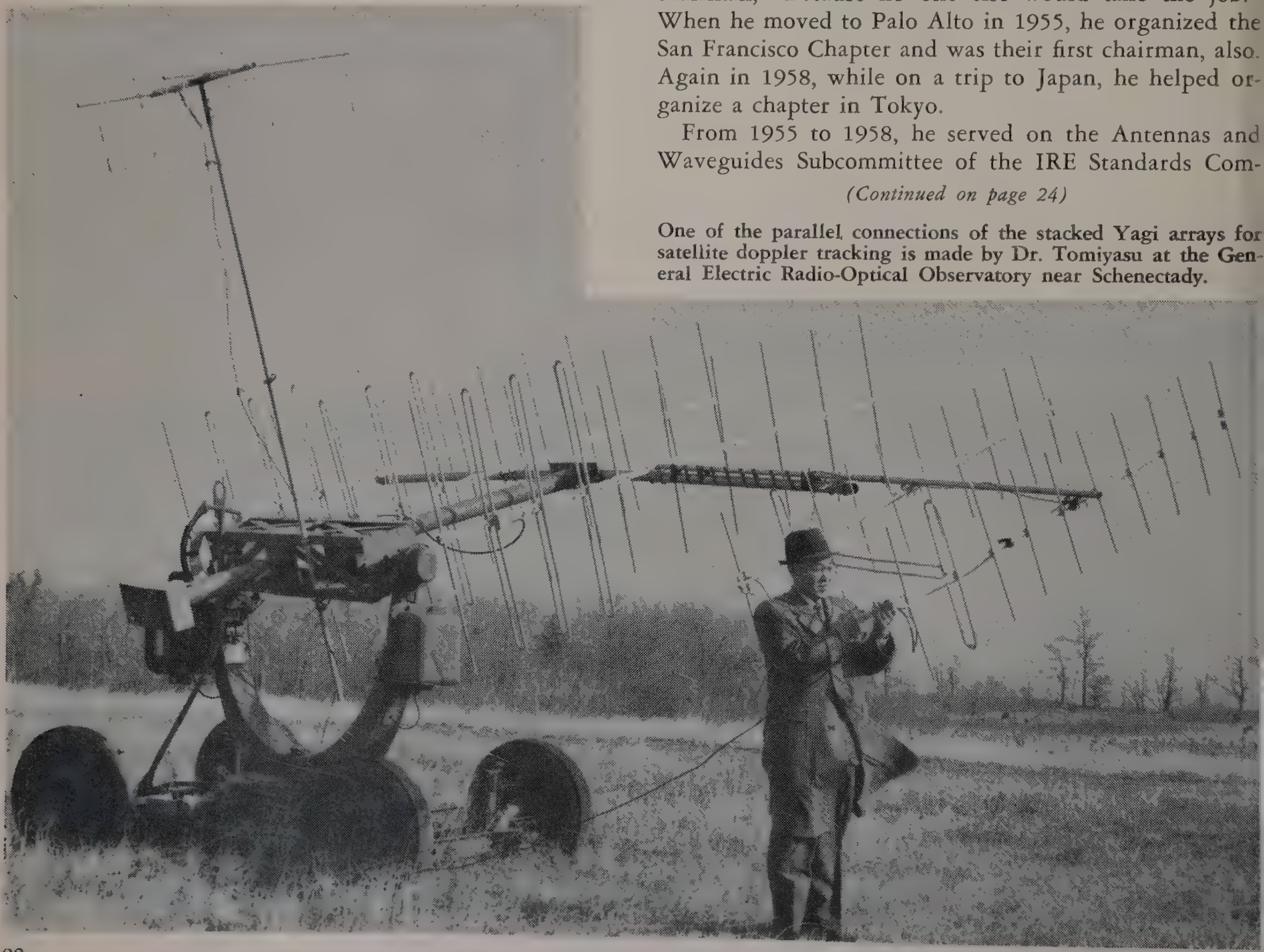


Dr. Tomiyasu shows the first model of a liquid cooled multiple-cell gas discharge unit from a Transvar - coupler high power duplexer.

Kiyo is a Senior Member of the IRE and has been very active in this organization. Since 1954, he has been a member of the Administrative Committee of the Professional Group on Microwave Theory and Techniques and is now Chairman. While at Sperry, he organized the Long Island Chapter of the PGMTT and was their first chairman, "Because no one else would take the job." When he moved to Palo Alto in 1955, he organized the San Francisco Chapter and was their first chairman, also. Again in 1958, while on a trip to Japan, he helped organize a chapter in Tokyo.

From 1955 to 1958, he served on the Antennas and Waveguides Subcommittee of the IRE Standards Com-

(Continued on page 24)



One of the parallel connections of the stacked Yagi arrays for satellite doppler tracking is made by Dr. Tomiyasu at the General Electric Radio-Optical Observatory near Schenectady.

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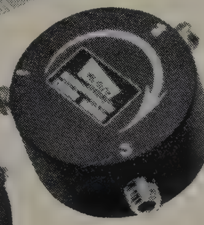
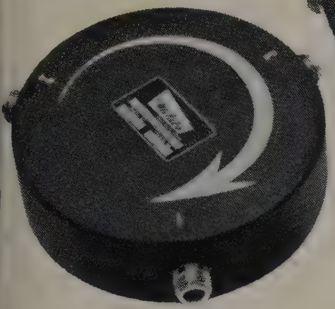
A Complete Line of Coaxial Circulators Combining these Outstanding Features:





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Ultra-low insertion loss

Small, compact, lightweight

Broad band coverage

Performance-proved

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heck the table below for the field-proved specifications of a few typical lelabs Circulator models, available now for off-the-shelf delivery. Nowhere lse can you find such a complete line of circulators to meet so many of your equirements with such high performance standards.

lere are Specifications that Speak for Themselves!

and Model Series	HF—		HU—	HL—		HS—		HC—
equency	200-600 mc		600-1000 mc	1.0-1.7 kmc		1.7-4.0 kmc		4.0-8.0 kmc
pical Model	HF-400	HF-420	HU-935	HL-130	HL-145	HS-225	HS-280	HC-565
equency	380-420	405-445	890-960	1.25-1.35	1.4-1.5	2.2-2.3	2.7-2.9	5.4-5.9
sertion Loss:								
Max. (at band ends)	0.6	0.5	0.4	0.3	0.3	.3	.3	.4
Typical/center	0.4	0.35	0.2	.2	.2	.2	.2	.2
olation:								
Min. (at band ends)	17 db	17 db	18 db	18 db	18 db	20 db	20 db	20 db
Typical/center	25 db	25 db	25 db	25 db	25 db	25 db	25 db	25 db
SWR (outputs terminated)								
Max. (at band ends)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Typical/center	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
iameters (max. excluding connectors)	5¼″	5¼″	3 11/16″	3″	3″	3″	3″	2″
leight	1⅞″	1⅞″	1⅞″	1¾″	1¾″	1⅛″	1⅛″	1⅛″
Veight (approx.)	4 lbs.	4 lbs.	1½ lbs.	1¼ lbs.	1¼ lbs.	8 oz.	8 oz.	6 oz.
Connectors (female)	Type N	Type N	Type N	Type N	Type N	Type N	Type N	Type N
ower:								
Average	100 w	100 w	5 w	5 w	5 w	5 w	5 w	5 w
*Peak	5 kw	5 kw	5 kw	5 kw	5 kw	5 kw	5 kw	5 kw
ice:	$400.00		$350.00	$310.00		$240.00		$225.00

*All units can, on request, be further miniaturized to meet your specifications. Size and weight reductions of 2 to 1 have been obtained for the S and C band units.

*These circulators can, on request, be provided with High Power or TNC Connectors.

*Rated with Type N Connectors.

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In addition to standard, temperature-stable units listed above, Melabs offers many circulator models to meet special requirements. Electronically tunable models HF, HU, HL Series are available with 300-500 MC tunable bandwidths. High-speed switchable models can be made to order for signal transfer or radiometer applications. Also available on special order are higher power models and individual units covering broader frequency bands. Simple modification converts these circulators to isolators with the same superior specifications.

Data subject to change without notice. Prices f.o.b. factory.

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TOMIYASU

(Continued from page 22)

mittee. He is presently a member of the Editorial Board of the IRE.

Because of his technical competence and his interest in IRE matters, Dr. Tomiyasu is frequently invited to serve as a Session Chairman at IRE conventions and PGMTT symposiums. In 1958, he served as Chairman of the Technical Program Committee at the PGMTT National Symposium held at Stanford University.

Kiyo's most active hobbies are photography and traveling. His interest in photography stems from his childhood when he took pictures in the Nevada desert. When traveling he takes pictures of everything so that "when I get home, I can see where I've been."

He has crossed the continent many times by car, train, bus, and plane. In planning his last trip by car, he noted that he had been in 45 of the 48 states. Naturally, he drove through the remaining three. In one of them, Kentucky, he took pictures of Lincoln's birthplace, Stephen Foster's home (My Old Kentucky Home), and Mammoth Caves. Subsequently, Hawaii and Alaska became states and presented a challenge. He has visited Hawaii on the way to Japan, but Alaska will have to be his next trip. He has also been in England and in every province of Canada except Yukon Territory. He'll probably cover that on his Alaska trip.

When Kiyo sees a scene he likes, he takes photographs of it from many angles. On his one-month trip to Japan he took 800 colored slides! (All his pictures are color transparencies). He now has a collection of more than 5000 slides, and, of course, they are all catalogued so that he can find any scene he wants in a matter of seconds.

Satellite orbits are discussed by Dr. Tomiyasu and Mr. Roy Anderson at General Electric's Radio-Optical Observatory nea Schenectady.

When the Tomiyasus have guests, they must expect t be shown scenes from his latest trip. Kiyo says that abou 70 slides is the limit of "tolerance" for most guest although an occasional enthusiast has sat through 200 He once tested his wife's tolerance. Eiko fell asleep afte 500 slides.

Kiyo occasionally gives illustrated travel lectures a women's clubs and other organizations. For this purpos he culls his collection down to 10% since many scene are redundant. He uses about 70 for a lecture, again fo reasons of tolerance.

Naturally, Kiyo felt that it was important to determin the best film for his hobby. He went about it quite sc entifically. Eiko wore a red dress, and Kiyo photographe her with the green Stanford hills and the blue sky i the background. He loaded his camera with three differ ent films in turn. These were Kodachrome, Anscochrome and Ektachrome. With each film he took a picture with the correct exposure, then one stop brighter, two stop brighter, one stop dimmer, and two stops dimmer. H now knows the best film to use for each color and wha latitude each film has.

Because of his IRE activities, Kiyo is well-known an well-liked throughout the country. His papers, in tech nical journals and at professional meetings, are com petent, and consequently, he is also respected for hi technical ability. If his name comes up, it is always with affection, and someone always says "By the way, did you ever see his slides?"

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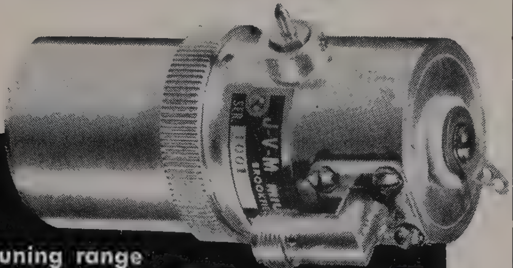

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Miniaturized MERCURY "10" cavities are precision engineered for restricted tuning range, minimum weight-frequency stability and temperature compensation. The "10" series includes 720 different cavities designed for maximum power and/or voltage ratings of a variety of tubes.

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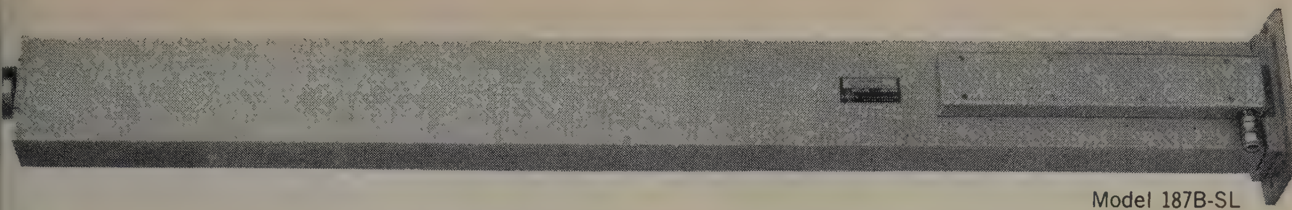
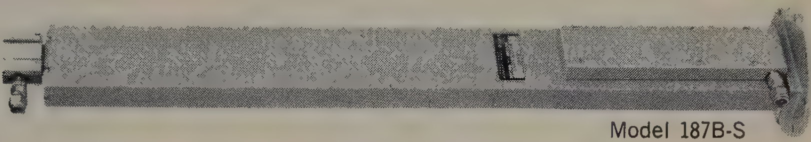


Model 187B-SL

OMPLETE LINE



Model 187B-S

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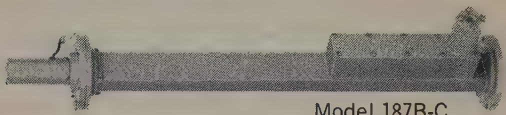
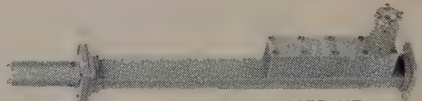


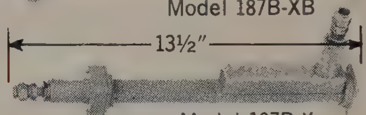
Model 187B-C

AVEGUIDE WATER LOADS



Model 187B-XB

or SL, S, C, XB and X Frequency Bands



Model 187B-X

Five models covering five bands

Three models useful in pressurized systems

VSWR less than 1.10

Can handle 2-20 kw average power

Low rf radiation

Calibration heaters in all models

These Sierra high-power waveguide terminations are extremely useful as dummy loads in calorimetric power-measuring systems. They feature rugged construction, with rigid plastic water tube mounted in waveguide section, diagonally oriented for impedance matching. Chokes and shielding minimize rf leakage, and a heater element built into each model permits rapid, accurate calibration of a calorimetric power-measurement system against a low-frequency standard.

HECK ALL THESE SPECIFIED ADVANTAGES!

Model Number:	187B-SL	187B-S	187B-C	187B-XB	187B-X
Frequency Range:	1.7 to 2.6 kmc	2.6 to 4.0 kmc	5.8 to 8.2 kmc	7.0 to 10.0 kmc	8.2 to 12.4 kmc
VSWR:	< 1.10 to 2.4 kmc < 1.15 to 2.6 kmc	less than 1.10	less than 1.10	less than 1.10	less than 1.10
Power Average: (Unpressurized)	20 kw	10 kw	5 kw	3 kw	2 kw
Peak Power:	2 megawatts	1 megawatt	500 kw	250 kw	150 kw
Max. Air Pressure:	*	*	45 psig	45 psig	45 psig
Waveguide:	RG-105/U	RG-75/U	RG-50/U	RG-51/U	RG-52/U
Connector:	UG-437A/U	UG-584/U	UG-344/U	UG-51/U	UG-39/U
Recommended Water Flow:	2 gpm for 10 kw	2 gpm for 10 kw	1 gpm for 5 kw	0.6 gpm for 3 kw	0.4 gpm for 2 kw
Pressure Drop at Rated Flow:	10 psi	10 psi	10 psi	10 psi	10 psi
Max. Water Pressure:	80 psig	80 psig	80 psig	80 psig	80 psig
Water Temperature:	0 to 70° C	0 to 70° C	0 to 70° C	0 to 70° C	0 to 70° C
Water Capacity:	18.5 cu. in.	3.5 cu. in.	0.85 cu. in.	0.42 cu. in.	0.20 cu. in.
Water Renewal at Rated Flow:	Once per 2.5 sec.	2 times per sec.	4.3 times per sec.	5.3 times per sec.	7.4 times per sec.
Heater Resistance:	4.5 ohms	9 ohms	14 ohms	20 ohms	20 ohms
Heater Rating:	10 kw at 2 gpm	5 kw at 1 gpm	3 kw at 1 gpm	1 kw at 0.6 gpm	1 kw at 0.4 gpm
Length:	50 in.	32 in.	20 in.	17.25 in.	13.5 in.
Price:	$600.00	$500.00	$425.00	$400.00	$375.00

Not pressurized

Data and prices subject to change without notice. Prices f.o.b. factory

For complete details, see your Sierra Representative or write direct.

NEW! Sierra also offers its Model 186 Series Coaxial Water Loads, covering dc to 4 kmc.

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MICROMEGA CORPORATION

Venice, California

Editor's Note — This is the first of a series in which we will present from time to time brief profiles of new companies in the microwave industry. It is intended to show the structure and capabilities of the new firms and perhaps serve as a guide to future entrepreneurs.

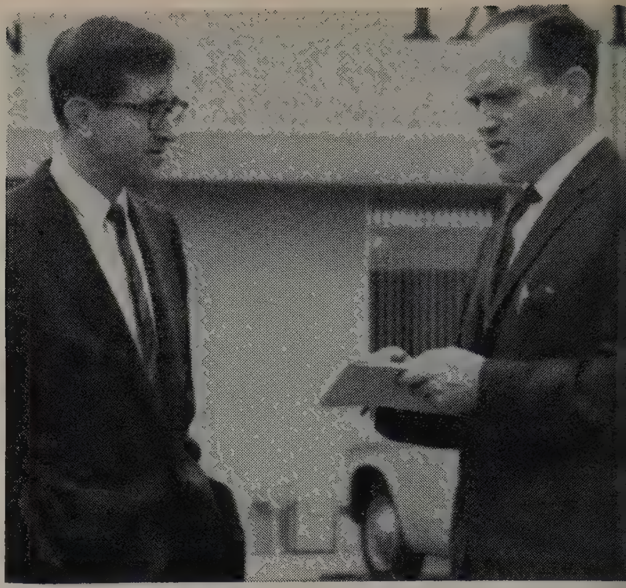
Literally interpreted, the name *Micromega* means "10^{-6} x 10^{6}" and therefore "unity." The company, however, considers the name, inspired by Voltaire's philosophical essay "Micromegas," to have a more spirited meaning: a small company with big ideas and big objectives.

HISTORY

What makes a group of people leave relative security in a large company and decide to "go on their own?" There are as many reasons as there are industrial firms. In the case of Micromega, the motivation was to establish an independent company that would participate in the growth of the microwave electronics industry; a company that would take full advantage of its small size, flexibility, and agility to exploit a number of technological breakthroughs in the field of solid state microwave electronics.

To start a company like Micromega one must be in a position to offer products and services that are either commercially novel or offer some important competitive feature. A technical staff is needed that has competence and experience, a staff capable of adapting itself to new situations as required by fast moving microwave technology. Finally, it is necessary to have adequate financial backing.

How did the founders of Micromega meet these conditions? E. Strumwasser and A. D. Berk had both been at Hughes Aircraft Company for many years and had served in supervisory positions in the areas of research and development. A. D. Berk, as head of the Solid State Applications Section of the Microwave Laboratory, had been in charge of the applied research on ferrites at microwave frequencies and had initiated the work on parametric amplifiers at Hughes. He had been in close cooperation with E. Strumwasser in both areas of ferrite and parametric devices. Mr. Strumwasser, as head of the Microwave Circuits Section, was instrumental in the design of some of the earliest practical microwave ferrite devices. Strumwasser and Berk were fully aware of the great opportunity that existed in the military and commercial exploitation of parametric amplifiers, solid state microwave sources, and ferrite devices. They were also convinced that successful pursuit of this opportunity demanded the flexibility of a small autonomous organization.



Dr. A. D. Berk, left, and E. Strumwasser — the founders c Micromega.

The initial staff of Micromega consisted of C. E. Nelson, R. L. Fogel, G. S. Uebele, H. M. Endler, R. B. Steinkolk, and M. R. Millet, all of whom are charter member and stock holders of the Corporation.

C. E. Nelson brought to Micromega eleven years c experience with General Electric and Hughes Aircraft i research, development and design of microwave filter ferrite tunable cavities, ferrite amplifiers, and parametri amplifiers. He and H. M. Endler were directly respons ble for the development and design of the first productior type S-band parametric amplifier. R. L. Fogel with eleve years of microwave experience at Sandia and Hughe made important contributions to the development of hig power ferrite duplexers and phase shifters and low fre quency compact ferrite components. G. S. Uebele, we known for his work on fast ferrite switches, passiv power limiters, and ultra-bandwidth circulators, cor pleted the team of ferrite engineers.

R. B. Steinkolk, was responsible for the first X-ban parametric amplifier to be installed in a system. H. M Endler, in addition to his important contributions in th field of parametric amplifiers, brought with him exper ence in radar transmitter circuitry and microwave cor ponents in general. M. R. Millet, with nine years c employment at Philco and Hughes, added experience i the field of diode mixers and provided additional help fc the effort in parametric amplifiers.

R. T. McCoy joined Micromega after its formation. H. experience in radar systems, which dates back to the day of the MIT Radiation Laboratory, had been recently com plemented by his contribution in the field of varacto multipliers and solid state microwave sources.

In FXR, Inc. of Woodside, New York, Micromeg found a financial backer that was successfully active in a allied field. The affiliation between the two companie was completed with a minimum of time.

Micromega was incorporated in Delaware, on Marc 18, 1960, with offices and plant facilities at 4134 Del Re Avenue, Venice, California.

COMPANY ACTIVITIES

Micromega's offices, laboratory, and shop facilities oc cupy a 10,000 square-foot modern plant. The microwav oratory is well equipped with the best available test uipment at most common frequency bands.

Micromega's main current activities are in the areas of v noise solid state amplifiers, varactor multipliers, all id state microwave sources, and ferrite devices. Most the work is necessarily custom-designed but effort being made to develop a product line.

Micromega was selected in June of 1960 by Philco rporation to develop certain S-band parametric amfiers for satellite tracking. This project is nearing comtion with all design objectives, not only attained, but ceeded. As a result, the sensitivity of the tracking rever will be increased by a minimum of 7 db. A comrcial model of this amplifier, which is an almost "off e shelf" item, can be packaged in various configurations fit particular needs and requires only two controls. It s been in increasing demand. Other models at L-, C-, d X-bands are also custom designed.

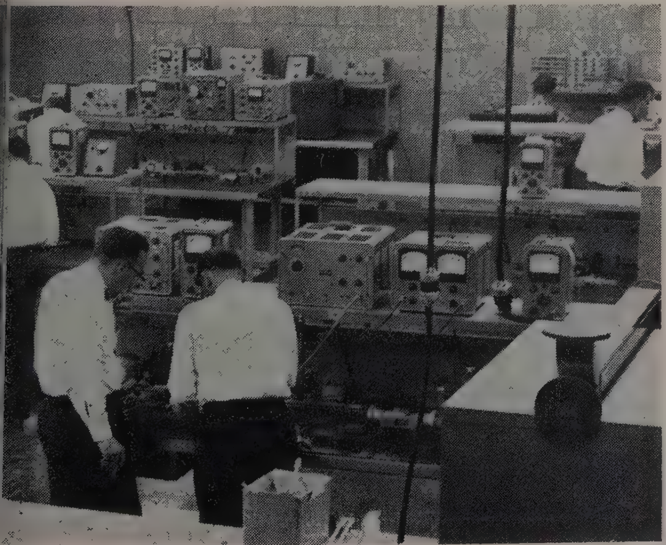
Varactor multipliers constitute one of the most imrtant and rapidly expanding products of the Company. eir outstanding characteristics are reliability, converon, efficiency, and compactness. With the addition of a ystal-controlled transistorized oscillator driver, these its become highly stable microwave sources for local cillator and telemetry transmitter applications.

Typical of Micromega's ferrite devices are the T- and -junction waveguide and stripline circulators, coaxial band isolators with unusually low VSWR, and fast icrowave switches and modulators. Under development e multi-channel switches, miniaturized coaxial and waveuide isolators, as well as electronically-controlled attenuars and phase shifters.

A watchful eye is being maintained on the general proess of research and development in neighboring fields microwave solid state electronics. These include tunnel ode and microwave transistor applications, masers, lasers, w temperature applications of varactors, molecular elec-onics, and Peltier coolers.

ORPORATE INFORMATION

Micromega is a privately-held corporation. The voting mmon stock is held by the charter members of Microega and FXR, Inc. The Board of Directors consists of E. Strumwasser, C. J. Burrell, A. D. Berk from Micromega and H. Feldmann and T. N. Anderson of FXR. The corporate officers are Mr. Strumwasser, president; Dr. Berk, executive vice president and treasurer; Mr. C. E. Nelson, secretary. Mr. Burrell also serves as the attorney of the Company.



The microwave laboratory is equipped for work at all principal frequency bands.

Discussing a technical problem are (left to right) E. Strumwasser, G. S. Uebele (standing), C. E. Nelson, M. R. Millet, R. B. Steinkolk (partially hidden), H. M. Endler, and R. L. Fogel.

In order to attract qualified personnel, a certain number of the authorized shares of the common stock has been earmarked for stock options. The Board of Directors has also approved the adoption of a liberal profit-sharing plan.

Minimum of "red tape," complete informality, speed of taking and implementing decisions are the blessings of a small company like Micromega — and the people at Micromega take full advantage of their opportunity. There have been cases, for example, when formal complete technical proposals have been delivered three days after receipt of request. The parametric amplifier activity is under the direction of Mr. Nelson. Mr. Fogel is in charge of the work on ferrite devices, and Mr. R. T. McCoy heads the work on varactor multipliers and solid state microwave sources.

After a period of approximately two months of organization and build-up of plant facilities, Micromega embarked in business operations in June of 1960. Since then the Company has accumulated a total of sales and backlog in excess of $150,000.00. On the basis of the existing and potential demand for its products, it would not be over-optimistic to expect annual sales of a million dollars in a year or two.

AFFILIATION WITH FXR, INC.

FXR, Inc. is the sole financial supporter of Micromega Corporation. The two companies are in closely allied fields so that their combined capability and experience is of mutual benefit. FXR will guarantee large production orders of Micromega until the latter develops its own production facilities. Micromega, in turn, hopes to contribute in the development and design of certain microwave components in the test equipment category which will be fabricated and sold by FXR.

The affiliation does not imply that Micromega is a subsidiary of FXR, Inc. Micromega is an independent Company with its management responsible solely to its Board of Directors.

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DIVISION OF SPERRY RAND CORP.
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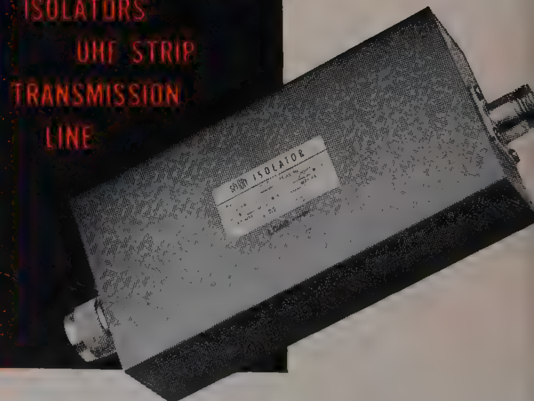
ANT

Coaxial isolators and circulators with no external magnets... Miniaturized by SPERRY

MODEL NO.	FREQ. (MC)	AVE. PWR. (WATTS)	MAX. INS. LOSS (db)	MIN. ISOLATION (db)	MAX. INPUT VSWR	DIMENSIONS (INCHES)	WEIGHT LBS.	OZ.
D44J7-5	225-300	5	5.0	18	1.30	3x1½x7⅝	3	4
D44J7-6	300-400	5	3.6	18	1.20	3x1¼x7⅝	3	4
D44J7	400-450	5	1.0	12	1.20	3x1½x7⅝	3	4
D44P1-7	450-550	5	1.0	15	1.20	3x1½x7⅝	3	4
D44P1-3	700-900	5	1.2	20	1.25	3x1½x7⅝	3	4
D44P1-5	870-990	5	1.2	20	1.20	3x1½x7⅝	3	4

ISOLATORS
UHF STRIP
TRANSMISSION
LINE


SPERRY ISOLATOR

SPERRY MICROWAVE ELECTRONICS COMPANY, *CLEARWATER, FLORIDA • DIVISION OF SPERRY RAND CORPORA*

Microline Instruments | *Radar Test Sets* | *Systems Instrumentation* | ***Solid State Devices and Materials*** | *Microwave Components and Ant*

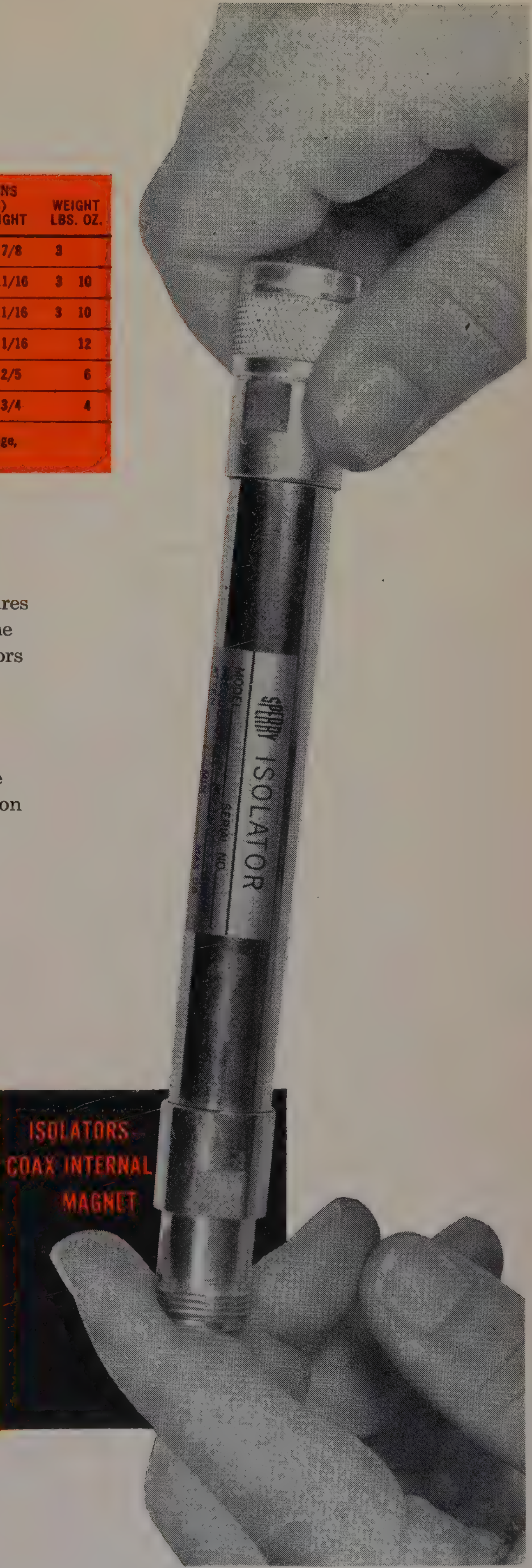
ODEL NO.	FREQ. (KMC)	AVE. PWR. (WATTS)	MAX. INS. LOSS (db)	MIN. ISOLATION (db)	MAX. INPUT VSWR	DIMENSIONS (INCHES) DIA.	HEIGHT	WEIGHT LBS.	OZ.
52J1	.40- .45	25	.7	17	1.30	5 7/16	7/8	3	
52P1	.90- .96	15	0.7	20	1.30	2 1/2	3 11/16	3	10
52L1	1.25- 1.35	10	0.7	20	1.30	2 1/2	3 11/16	3	10
52S1	2.7 - 2.9	10	0.5	20	1.30	1 5/8	2 1/16		12
52C1	5.4 - 5.9	15	0.5	20-30	1.30	1 2/5	1 2/5		6
52C1-2	5.4 - 5.9	15	0.5	20-30	1.30	1 1/2	3/4		4

Physical dimensions on the D52D1, L1 and S1 subject to change in the near future. This change, if made, will be aimed at improving manufacture of the units plus improving reproducibility.

erry's constant effort to reduce the size and weight its devices without sacrificing any of their desirable features performance characteristics has resulted in a complete line coaxial and strip transmission line isolators and circulators niaturized to a degree that only Sperry research uld have made possible.

hese isolators and circulators have no external rmanent magnets, possess excellent electrical performance d almost perfect magnetic shielding. Designed for operation om 225 mc to 6000 mc with 10 percent bandwidths. iniaturized units with wider bandwidths and stable eration under rigid environmental conditions e available on special order.

mple units available from stock. We will welcome your quiries for more complete information.



ISOLATORS COAX INTERNAL MAGNET

ODEL NO.	FREQ. (KMC)	AVE. PWR. (WATTS)	MAX. INS. LOSS (db)	MIN. ISOLATION (db)	MAX. INPUT VSWR	LENGTH* (INCHES)	WEIGHT (OZ.)
44L7	1.25 - 1.35	5	0.9	15	1.20	6 39/64	6¼
44L7-7	1.24 - 1.40	5	0.8	12	1.20	6 39/64	6¼
44L7-6	1.435- 1.535	5	0.6	16	1.15	6 39/64	6¼
44L11-2	.96 - 1.215	10	0.8	10	1.20	11 11/16	10
44L33-25	1.7 - 2.3	10	1.0	13	1.20	10	8
44L33-5	2.0 - 2.7	10	2.0	40	1.20	11 55/64	14
44S7	2.7 - 3.1	5	0.9	15	1.20	4 11/32	5
44C7	5.4 - 5.9	5	0.9	15	1.20	4 11/32	5

ll units have a maximum diameter of 25/32 inch.

Circle Reader Service Card 17

Industry News

ACKERLIND JOINS LYNCH R&D STAFF

Dr. E. Ackerlind has joined the research and development staff of Lynch Communications Systems, Inc., San Francisco, Cal., designers and manufacturers of telephone, microwave, data transmission and control equipment. In making the announcement Donald E. Campbell, Lynch president, stated Dr. Ackerlind would be engaged primarily on new systems design.

Dr. Ackerlind is an electronics design engineer and consultant with twenty-five years experience in electronic research, development and design. Since 1957 he has been an electronics consultant for private industry. He has held key positions in many governmental and commercial engineering organizations including Radio Corporation of America, Jet Propulsion Laboratory of the California Institute of Technology, Northrop Aircraft and Naval Research Laboratory.

He received his BEE from Polytechnic Institute of Brooklyn, his MS in EE from Columbia University and was awarded the Doctor of Electrical Engineering degree in 1937 by the Polytechnic Institute of Technology and the University of California at Los Angeles.

Author of several published papers, Dr. Ackerlind also holds a number of patents. He is a senior member of the Institute of Radio Engineers and holds memberships in a number of professional and honorary societies including Sigma Xi, Eta Kappa Nu, the American Institute for Electrical Engineers, Association for Computing Machinery and Society for Industrial and Applied Mathematics.

— m w j —

ARINC ACQUIRES ROBERT STRAUSS

Robert Strauss has recently joined Arinc Research Corp., Washington, D. C. He will be associated with the reliability programs that Arinc conducts for the Armed Forces and Industry.

His responsibilities will be, in part, devoted to tasks in the electron tube device field with particular emphasis on microwave type devices.

Previously, Mr. Strauss was an Engineering Supervisor in the Microwave Tube Group of the Sperry Rand Electronic Tube Division, Gainesville, Florida. For the past six years he has been engaged in the development, product refinement, and production of traveling wave type tubes and klystrons. From 1948 to 1954 Mr. Strauss was a member of the Technical Staff of Bell Telephone Laboratory, Inc., associated with the development of various electron devices.

Mr. Strauss holds degrees from Cornell University (BME) and Lehigh University (MSEE). He is also a member of IRE, a member of ASQC and Eta Kappa Nu as well as a registered professional engineer in the State of New York.

— m w j —

GARR DESIGNATED CORPORATE DIRECTOR

Donald E. Garr has been named corporate director of engineering for Raytheon Co., Waltham, Mass. In his new post, Garr will report to Martin Schilling, Raytheon's vice president, engineering and research.

Associated with General Electric since 1936, Garr's engineering background includes management of development programs in industrial electronic systems, military fire control and aircraft electronic systems, data handling systems, human engineering and computer development.

A 1936 graduate of Kansas State College, Garr holds a BSEE degree and is a licensed professional engineer in the state of New York. He is a Fellow and past officer of the American Institute of Electrical Engineers, senior member of the Institute of Radio Engineers, and a member of both the American Society of Mechanical Engineers and the New York State Society of Professional Engineers.

Garr holds 19 patents in the fields of amplidynes and magnetic amplifiers.

— m w j —

(Continued on page 34)

Circle Reader Service Card 18 ➧

A Sym

MODEL 500
MICROWAVE
POWER SUPPLY

PRICE: $1690

MODEL 515
POWER SUPPLY

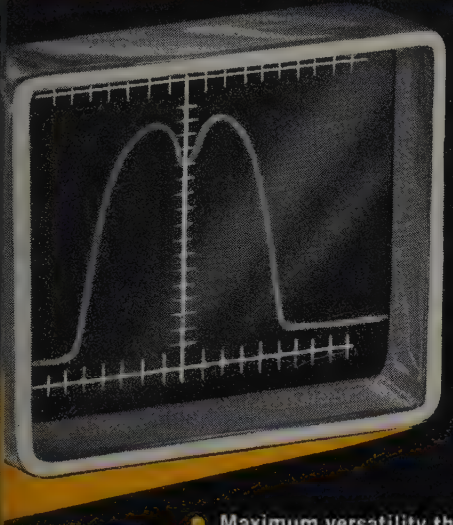
A low noise Klystron Power Supply with excellent regulation to accommodate medium voltage tubes.

- Repeller ... 20-1000 vdc, <0.5 mv rms ripple
- Beam...200-800 vdc, 0-100 ma, <3 mv rms ripple
- Heater...6.3-12.6 vdc, 0-2 amp
- Internal Modulation
- Overload Protection

PRICE: $750

MICROWA

Reliability IN THE MICROWAVE FIELD



A "NEW SCOPE"

IN MICROWAVE POWER SUPPLIES

The FIRST laboratory microwave power supply completely integrated into the measuring system.

Integral dc oscilloscope with sweep functions derived from the internal modulator...
... eliminates ... auxiliary oscilloscope

- Maximum versatility through the use of floating 2-terminal outputs, plug-in precision modulators and voltage range extension units.
- Continuously variable and regulated dc filament supply.
- Precision (1000.0 cps) square-wave modulator with internal synchronization voltage derived from a tuning fork.
- Low noise and ripple, excellent regulation.
- 200 ma output available over entire voltage range without de-rating.
- 2 independently variable repeller voltages.

SPECIFICATIONS

	VOLTAGE	REGULATION From 105-125 vac	INTERNAL IMPEDANCE	RMS RIPPLE	DIAL ACCURACY
Beam	Continuously variable 0-2.2 kvdc at 0-200 ma max. (2.2-4.2 kvdc optional)	±0.005%	<0.2 ohms	1 mv	0.05% resolution 0.5% resettability
Grid	—250 to +100 vdc continuously variable 0-20 ma	±0.005%	<0.5 ohms	1 mv	0.05% resolution 1% resettability
Filament	0-12.6 vdc continuously variable 0-5 amp dc	1%	———	1%	———
Repeller	1) 1000 vdc fixed 2) 20-1000 vdc continuously variable 3) 20-1000 vdc continuously variable	±0.005%	<100 k ohm	0.5 mv	0.05% resolution 0.5% resettability

Modulation
- Plug-in capability including square wave at 1000.0 cps and 1000 cps ±10%, sawtooth at 40-400 cps, and variable frequency square wave 200-4000 cps.
- Synchronization and external CRO drive outputs available.

Microwave Dynamics' accomplished staff is also applying its vast experience to the "custom" solution of a wide variety of challenging high-voltage power supply problems. An example of this microwave capability is a new achievement in airborne power supply systems—solid state techniques and unique packaging concepts provide, in miniature size, previously unobtainable voltages at extremely high altitudes.

We welcome the opportunity to be of assistance in the solution of your high-voltage problems, however complex.

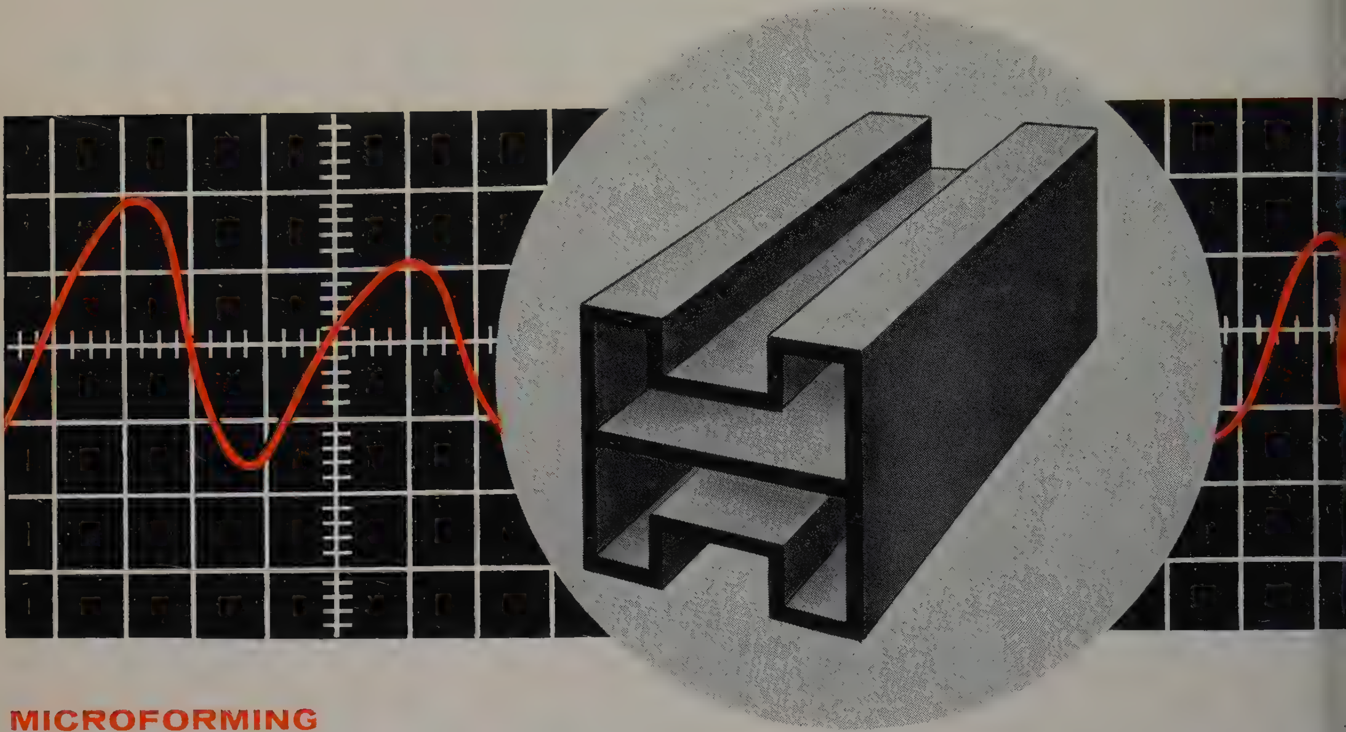
Complete literature available on request

YNAMICS CORPORATION

a subsidiary of Talley Industries, Inc.

PLAINVIEW INDUSTRIAL PARK, PLAINVIEW, L. I., N. Y. • OVerbrook 1-6811

New **MICROFORMED**®
PRECISION Waveguide Tubing



MICROFORMING

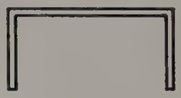
—a precision process developed by AERO-CAL METAL FABRICATORS, INC. for successfully producing over a *quarter million* feet of special S-band, rectangular and channel waveguide tubing to standard MICROFORMED tolerances of ± .002″. Normal S-band tolerances are ± .005″. This achievement by AERO-CAL METAL FABRICATORS, INC., in addition to experimental production of other configurations, has proved the feasibility of proportionately reducing the tolerance spread in cross-sections smaller than S-band. Surface finish, twist, bow, perpendicularity and concentricity show similar improvement.

MICROFORMING makes practical the cross-sections illustrated and is not limited to standard waveguide materials. AERO-CAL METAL FABRICATORS, INC. can produce MICROFORMED S, C, X, and K_u-band waveguides. Airborne component weight reductions of 50% or more are possible with MICROFORMED thin-wall cross-sections. Customer-specified cross-sections and materials can be produced with relatively short lead time. For the first time, MICROFORMING puts quantity production of precision waveguide tubing ahead of the state-of-art requirements.

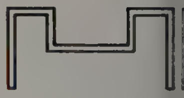
TAKE A GIANT STEP FORWARD WITH MICROFORMING

AERO-CAL
METAL FABRICATORS, INC.
a subsidiary of Coast Pro-Seal & Mfg. Co.

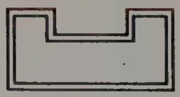
Sales and Engineering Offices: 15524 S. Broadway, Gardena Calif. *FAculty* 1-2454
Mailing Address: P.O. Box 57248, Flint Station, Los Angeles 57, California
Administrative Offices: 2235 Beverly Boulevard, Los Angeles 57, California



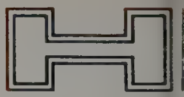
CHANNEL



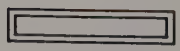
RIDGED CHANNE



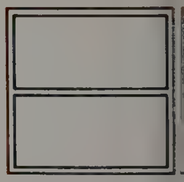
SINGLE RIDGED



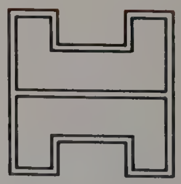
DOUBLE RIDGED



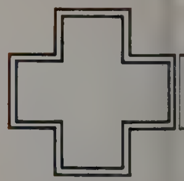
TOLL TICKET



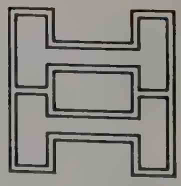
BI-RECTANGULA



BI-SINGLE RIDGED



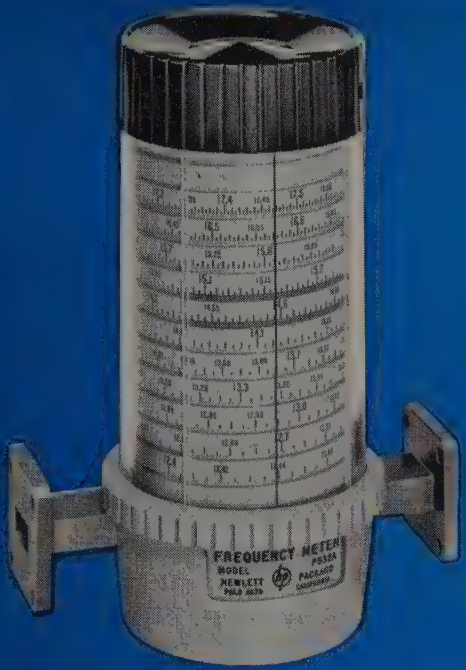
CROSSED



BI-DOUBLE RIDGED

SQUARE

Circle Reader Service Card 16



COMPLETE FREQUENCY COVERAGE

Highly accurate,
direct reading
wide band

FREQUENCY METERS

3.95 to 40 KMC!

low hp offers you high quality, moderately priced recision Frequency Meters covering eight imporant microwave bands.

Frequency is read directly in KMC on the large, recisely calibrated spiral scale. No charts or interolation are required. Accuracy is high—up to 0.06% ncluding 0 to 100% relative humidity change, 20° C emperature variation and dial accuracy (See Speciications).

Model 532 Frequency Meters comprise a special waveguide section mounting a high Q resonant cavty tuned by a choke plunger. A 1 db or greater dip n output indicates resonance. There are no spurious modes or resonances. Tuning is by a precision ead screw, spring loaded to eliminate backlash. Minimum calibration spacing is 1/32″ to provide good resolution.

SPECIFICATIONS

Model No.	Overall Accuracy (%)	Frequency Range KMC	Dial Calib. Accuracy (%)	Calibration Increment (MC)	Max. Temp. Coefficient % per ° C	Price
G532A	0.065	3.95 - 5.85	0.033	1	0.0012	$325.00
J532A	0.065	5.30 - 8.20*	0.033	2	0.0012	300.00
H532A	0.075	7.00 - 10.0	0.040	2	0.0015	195.00
X532B	0.080	8.20 - 12.4	0.050	5	0.0010	150.00
M532A	0.085	10.0 - 15.0	0.053	5	0.0012	275.00
P532A	0.100	12.4 - 18.0	0.068	5	0.0012	210.00
K532A	0.110	18.0 - 26.5	0.077	10	0.0013	230.00
R532A	0.120	26.5 - 40.0	0.083	10	0.0017	250.00

K and R band models available with circular flange adapters; specify K532AC and R532AC respectively.

*When used between 5.3 to 7.5 KMC, or 5.7 to 8.2 KMC, single mode resonance is achieved.

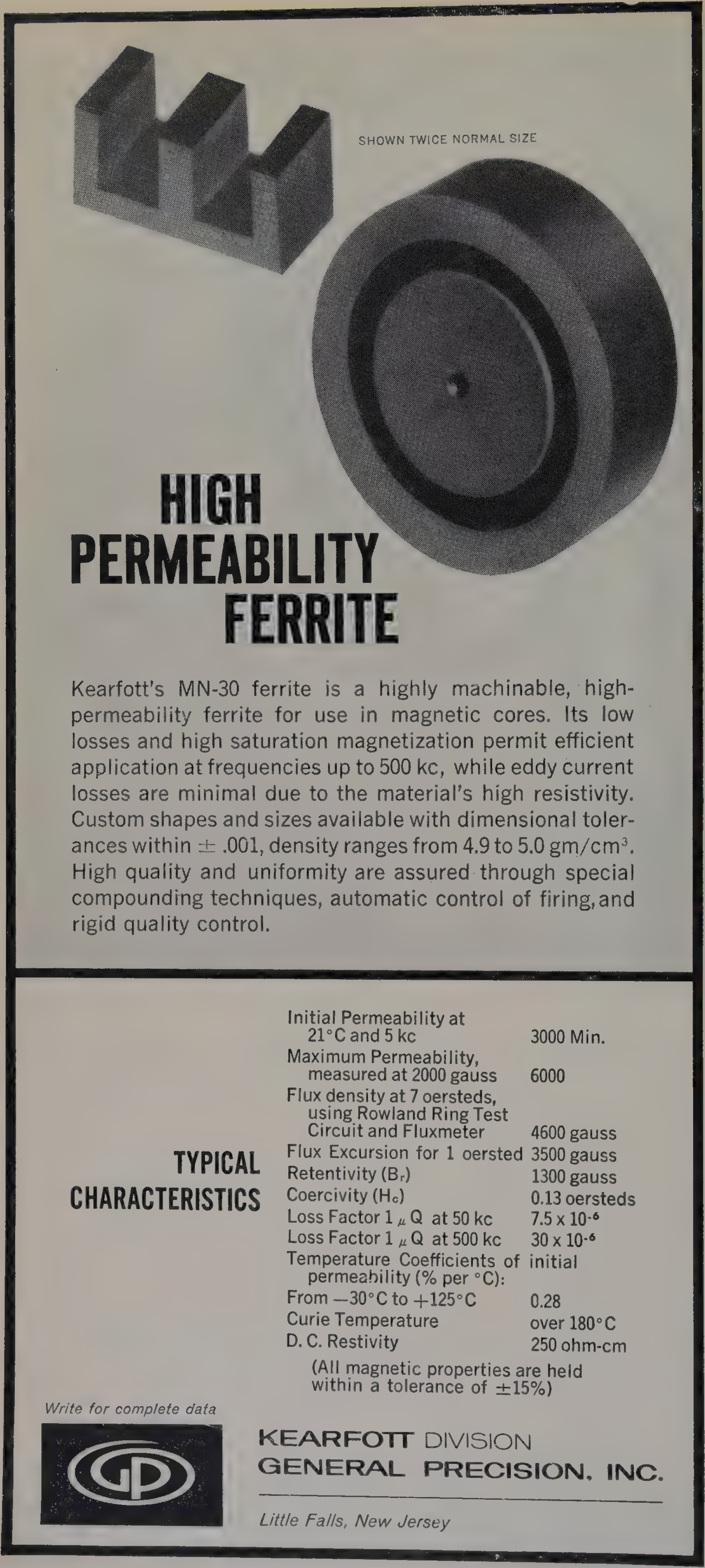
Data subject to change without notice. Prices f.o.b. factory.

For complete details, call your hp representative or write direct

HEWLETT-PACKARD COMPANY

1052C Page Mill Road — Palo Alto, California, U.S.A.
Cable "HEWPACK" — DAvenport 6-7000
Sales representatives in all principal areas
HEWLETT-PACKARD S.A.
Rue du Vieux Billard No. 1 — Geneva, Switzerland
Cable "HEWPACKSA" — Tel. No. (022) 26. 43. 36

complete instrumentation for microwave measurements



SHOWN TWICE NORMAL SIZE

HIGH PERMEABILITY FERRITE

Kearfott's MN-30 ferrite is a highly machinable, high-permeability ferrite for use in magnetic cores. Its low losses and high saturation magnetization permit efficient application at frequencies up to 500 kc, while eddy current losses are minimal due to the material's high resistivity. Custom shapes and sizes available with dimensional tolerances within ± .001, density ranges from 4.9 to 5.0 gm/cm^3. High quality and uniformity are assured through special compounding techniques, automatic control of firing, and rigid quality control.

TYPICAL CHARACTERISTICS

Initial Permeability at 21°C and 5 kc	3000 Min.
Maximum Permeability, measured at 2000 gauss	6000
Flux density at 7 oersteds, using Rowland Ring Test Circuit and Fluxmeter	4600 gauss
Flux Excursion for 1 oersted	3500 gauss
Retentivity (B_r)	1300 gauss
Coercivity (H_c)	0.13 oersteds
Loss Factor 1 μ Q at 50 kc	7.5 x 10^{-6}
Loss Factor 1 μ Q at 500 kc	30 x 10^{-6}
Temperature Coefficients of initial permeability (% per °C):	
From —30°C to +125°C	0.28
Curie Temperature	over 180°C
D. C. Restivity	250 ohm-cm

(All magnetic properties are held within a tolerance of ±15%)

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

Industry News

(Continued from page 30)

PAPERS REQUESTED FOR NAECON SESSIONS

An invitation to submit papers f presentation at the Thirteenth Annu National Aerospace Electronics Conf ence (NAECON) has been issued by R ald G. Stimmel, Chairman of the Pap Committee.

The Conference, will be held on M 8, 9, 10, 1961 at the Biltmore and Mi Hotels in Dayton, Ohio. Its theme will "Electronics Technology in the Aerosp Age."

The technical papers program w schedule only four concurrent sessio during each conference period, w topics selected and balanced to minim conflicts of audience interest. Critiq periods will follow the formal papers each session.

The following subjects have been su gested as session topics: Energy Conv sion Systems; Solid State Devices; Rad Astronomy; Ground Support Equipmen Aerospace Reconnaissance Systems; Mo cular Electronics; Magnetohydordynam Aerospace Systems Integration; Bioni Aerospace Communications; Antenn and Propagation; Aerospace Enviro ment; Vehicle-Borne Computers; Gu ance and Control Systems; Telemetr Systems Management; Microwave Tub and Circuits; Scientific Education; Au Technique; Electromagnetic Interferen and Electric Propulsion.

Detailed instructions and deadlines f required data can be obtained by writi to Ronald G. Stimmel, Chairman, Pap Committee, 809 Larriwood Aven Dayton 29, Ohio.

—mwj—

QUARLES WILL DIRECT LONG-RANGE MILITARY PLANNING

Dr. Gilford G. Quarles has been pointed to the new post of director long-range military planning of T Bendix Corp., Detroit, Mich., it has be announced by A. P. Fontaine, executi vice president.

Dr. Quarles, who has been chief scien fic adviser of the U. S. Army Corps Engineers, will assist in the establishme of a corporate plan to meet the need future defense and government requi ments. In addition, Dr. Quarles w establish a technique for evaluating lo range trends in weapons systems and government-support systems.

From 1956 to 1958 Dr. Quarles w scientific and technical consultant to commanding general of the U. S. Ar Ballistic Missile Agency, Huntsville, A In 1958 he was named chief scientist the U. S. Army Ordnance Missile Co mand at Redstone Arsenal, Ala.

He is a member of the American Ph cal Society, American Institute of Elec cal Engineers, American Society Engineering Education, and the Ameri Ordnance Association.

—mwj—

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WEITMAN JOINS GENERAL CROWAVE CORPORATION AS SENIOR ENGINEER

Ar. Irwin Weitman, formerly with Electronics, Inc., has joined the eral Microwave Corp., Farmingdale, ., in the capacity of senior engineer. Weitman will have responsibility for lesign and development of proprietary ronic products as well as military pment in the microwave-electronic s.

r. Weitman's previous experience ines two years with PRD Electronics, where he was employed as a project neer, one year with Polarad Electronand three years with Electron Devices,

r. Weitman received the degree of E from Columbia University where s presently studying in the Graduate ol. He is a member of Tau Beta Pi, Kappa Nu and the Institute of Radio ineers.

—*mwj*—

GORHAM ELECTRONICS NNOUNCES NEW ALUMINUM DIP-BRAZING CAPABILITY

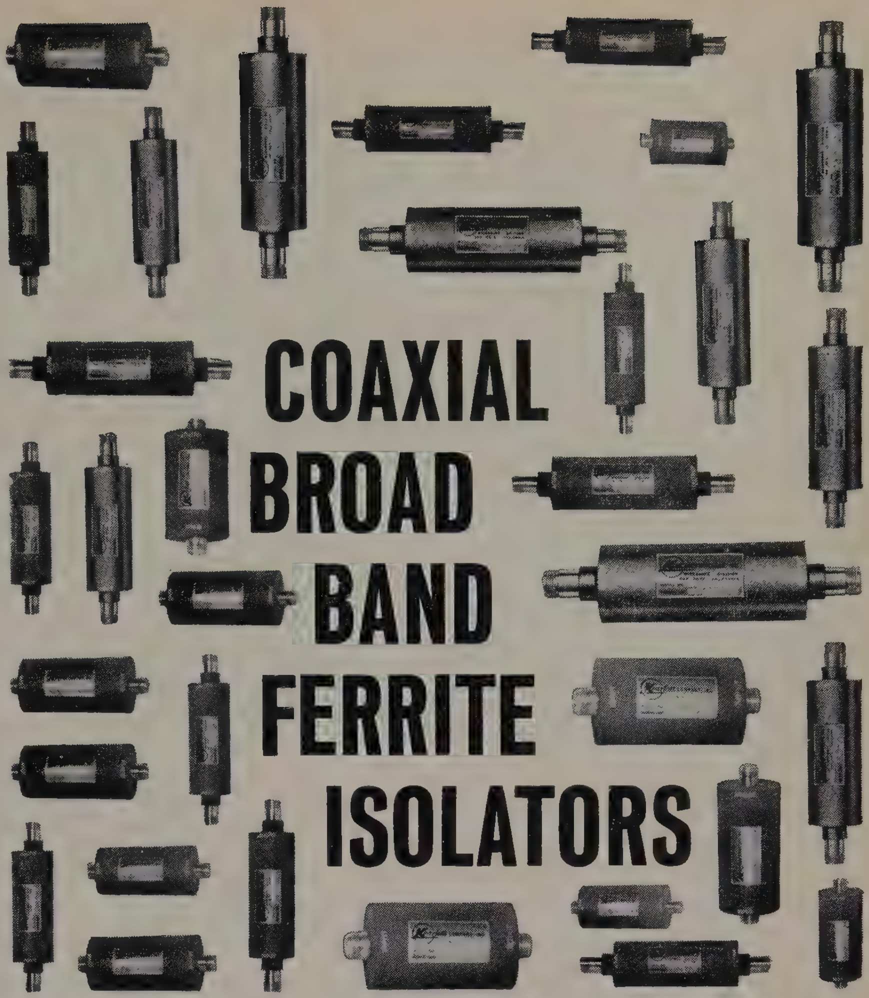
orham Electronics, Providence, R. I., ision of the Gorham Manufacturing npany, has announced the installation new Aluminum Dip Brazing Department.

Completely equipped with the latest aces and ovens, this new facility repnts one of the most modern installas servicing the Microwave Industry.

Gorham's integrated service concept, ounced some months ago, permits plete "under one roof" service for rowave sub-assemblies.

—*mwj*—

(*Continued on page 36*)



COAXIAL BROAD BAND FERRITE ISOLATORS

IN SIZES FOR EVERY APPLICATION

Now—from Kearfott, a new and broader line of Ferrite Isolators to satisfy the most exacting requirements of band width and isolation. Combining low unit loss characteristics with compactness and light weight, this new series of Kearfott Coaxial Isolators is available from present stock. Immediate selection and faster delivery is assured . . . *precision performance proven.*

A FEW OF THE TYPICAL SPECIFICATIONS

MODEL	FREQUENCY	ISOLATION	INSERTION LOSS	VSWR
C991100-402	1.2—2.6 KMC	10 DB Min.	1.0 DB Max.	1.20
C992100-405	2.0—2.5 KMC	30 DB Min.	.8 DB Max.	1.20
C992100-404	2.0—4.0 KMC	10 DB Min.	1.0 DB Max.	1.20
C992100-407	3.0—3.5 KMC	35 DB Min.	.8 DB Max.	1.20
C993100-401	4.0—8.0 KMC	10 DB Min.	1.0 DB Max.	1.20
C994100-403	7.0—9.0 KMC	25 DB Min.	.8 DB Max.	1.20

Complete information on these or all of the models is available by directing inquiries to: 14844 Oxnard Street, Van Nuys, California, or the sales office in your area.

GP

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

SALES OFFICES SEATTLE, WASH. VAN NUYS, CALIF. PHOENIX, ARIZ. DAYTON, OHIO CLIFTON, N.J. PALO ALTO, CALIF. SAN DIEGO, CALIF. DALLAS, TEX. CHICAGO, ILL. WASHINGTON, D.C.

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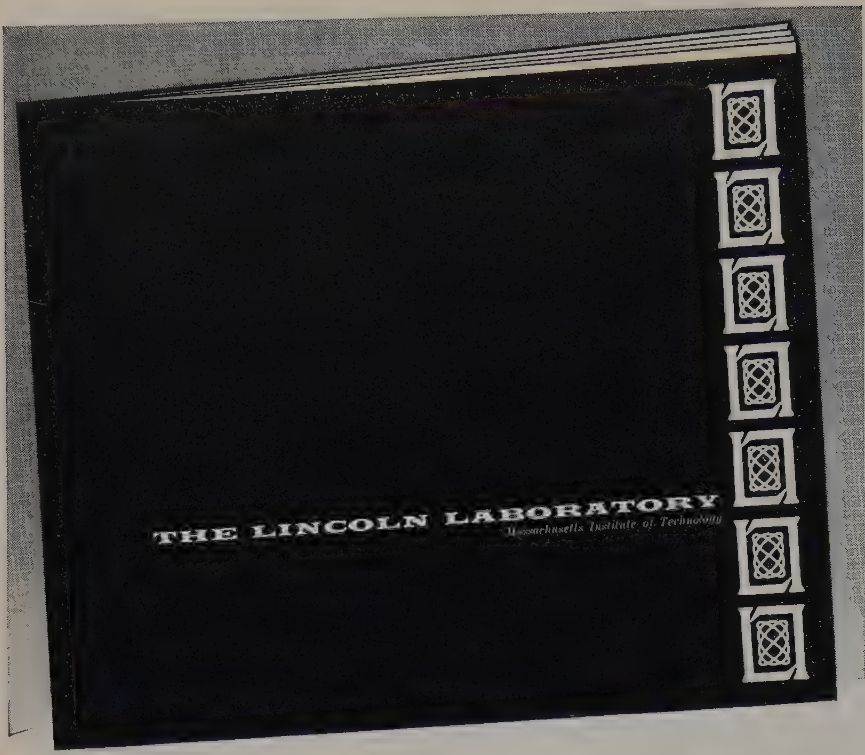


Lincoln Laboratory is supplementing its staff. The Laboratory is engaged in basic air defense research for the space age. This expanding program is a natural outgrowth of our advanced research and development in the fields of Radio Physics, Radar, Systems Studies, Satellite Surveillance, Computer Technology and Solid State Physics. Senior scientists are invited to join the Laboratory in solving urgent problems of importance to the defense of the United States.

The Laboratory is seeking qualified specialists in:

RADIO PHYSICS and ASTRONOMY
NEW RADAR TECHNIQUES
SOLID STATE PHYSICS and METALLURGY

- **A more complete description of the Laboratory's work will be sent to you upon request.**

Research and Development
LINCOLN LABORATORY
Massachusetts Institute of Technology
BOX 25
LEXINGTON 73, MASSACHUSETTS

Industry News

(Continued from page 35)

SPACE ELECTRONICS ANNOUNCE TWO APPOINTMENTS

Space Electronics Corporation, Glendale, Cal., has announced the appoin ments of Dr. Samuel Sensiper and D William Pohlman as director a associate director, respectively, of t newly formed Command and Cont Laboratories.

Dr. Sensiper joins SEC after nine yea with Hughes Aircraft Company where h most recently served as senior staff con sultant in the Research Laboratory. H also has been associated with Sperr Gyroscope as head of the Microwave De velopment department and as a sta member of Massachusetts Institute Technology.

Dr. Sensiper was awarded both a B and PhD degree from Massachuset Institute of Technology. He received hi MS degree from Stanford University. H is a fellow of the IRE.

Dr. Pohlman previously served a associate director of systems for th western division for Collins Radio. H background also includes assignmen with Space Technology Laboratories an Radioplane division of Northrop Corpor tion. At one time he was director of th technical staff at White Sands Missi Range.

He received his BS degree from Lehig University and his PhD degree fro Massachusetts Institute of Technology.

—*mwj*—

STUDY UNDERTAKEN FOR AIR DEVELOPMENT CENTER

The Caswell Electronics Corp., Sa Jose, Cal., and University of Michiga Research Institute have undertaken a stu program to investigate possible uses ferro-electric materials in microwave d vices. The study is under the sponsorshi of the Rome Air Development Center, A Research and Development Comman Griffiss Air Force Base, Rome, New Yor

The University of Michigan Resear Institute, under the direction of Dr. Hov ard Diamond, has entered into the stu as subcontractor to develop improve materials for microwave applications.

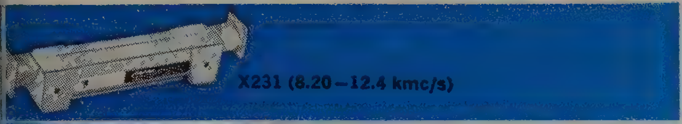
The program calls for work on sever different types of microwave devices, wit investigation aimed at materials showin both ferro-electric and ferro-magnet properties.

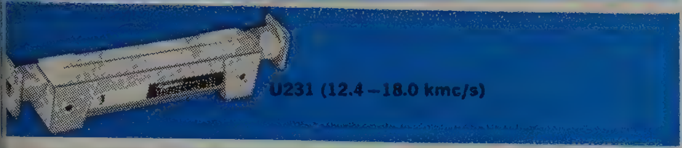
Robert Orrick, who heads the work f the Caswell Electronics Corporatio stated that, "Our initial studies are bein directed towards the development of rap phase shifters. It is too early to tell ho successful the investigation will be, b in view of the limited research which h been done in the past and the availabili of several new materials, we believe th this field offers the possibility of a sig ficant new advance in the art."

—*mwj*—

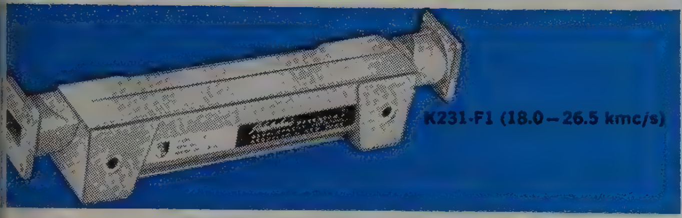
(Continued on page 66)

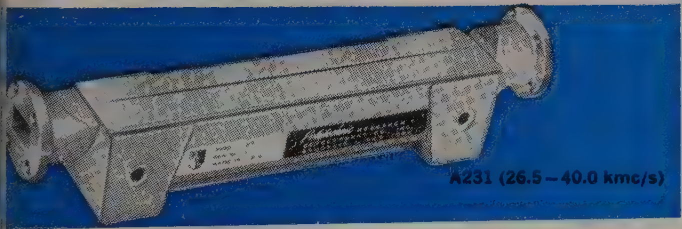
ONE FOR ALL and ALL NEW


X231 (8.20–12.4 kmc/s)

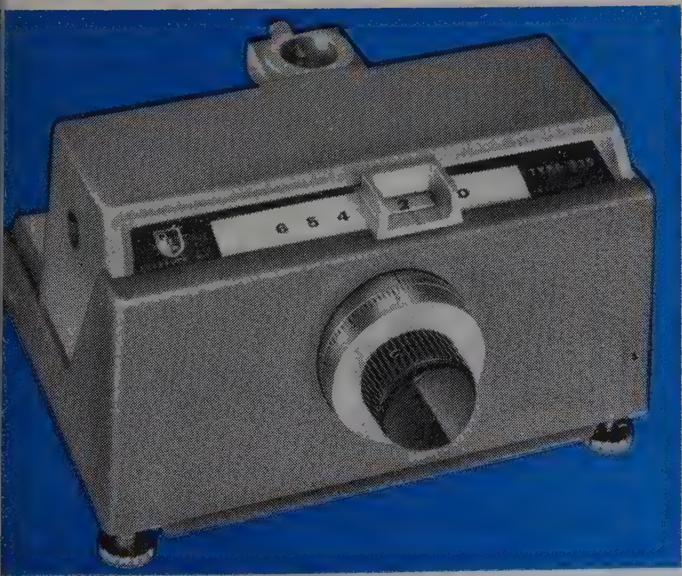

U231 (12.4–18.0 kmc/s)

K231 (18.0–26.5 kmc/s)


K231-F1 (18.0–26.5 kmc/s)


A231 (26.5–40.0 kmc/s)

A231-F1 (26.5–40.0 kmc/s)



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X231	8.20-12.4	1 x 1/2	9	UG-39/U
U231	12.4-18.0	.702 x .391	9	UG-419/U
K231	18.0-26.5	.500 x .250	9	UG-425/U
K231-F1	18.0-26.5	.500 x .250	9	UG-595/U
A231	26.5-40.0	.360 x .220	9	UG-381/U
A231-F1	26.5-40.0	.360 x .220	9	UG-599/U

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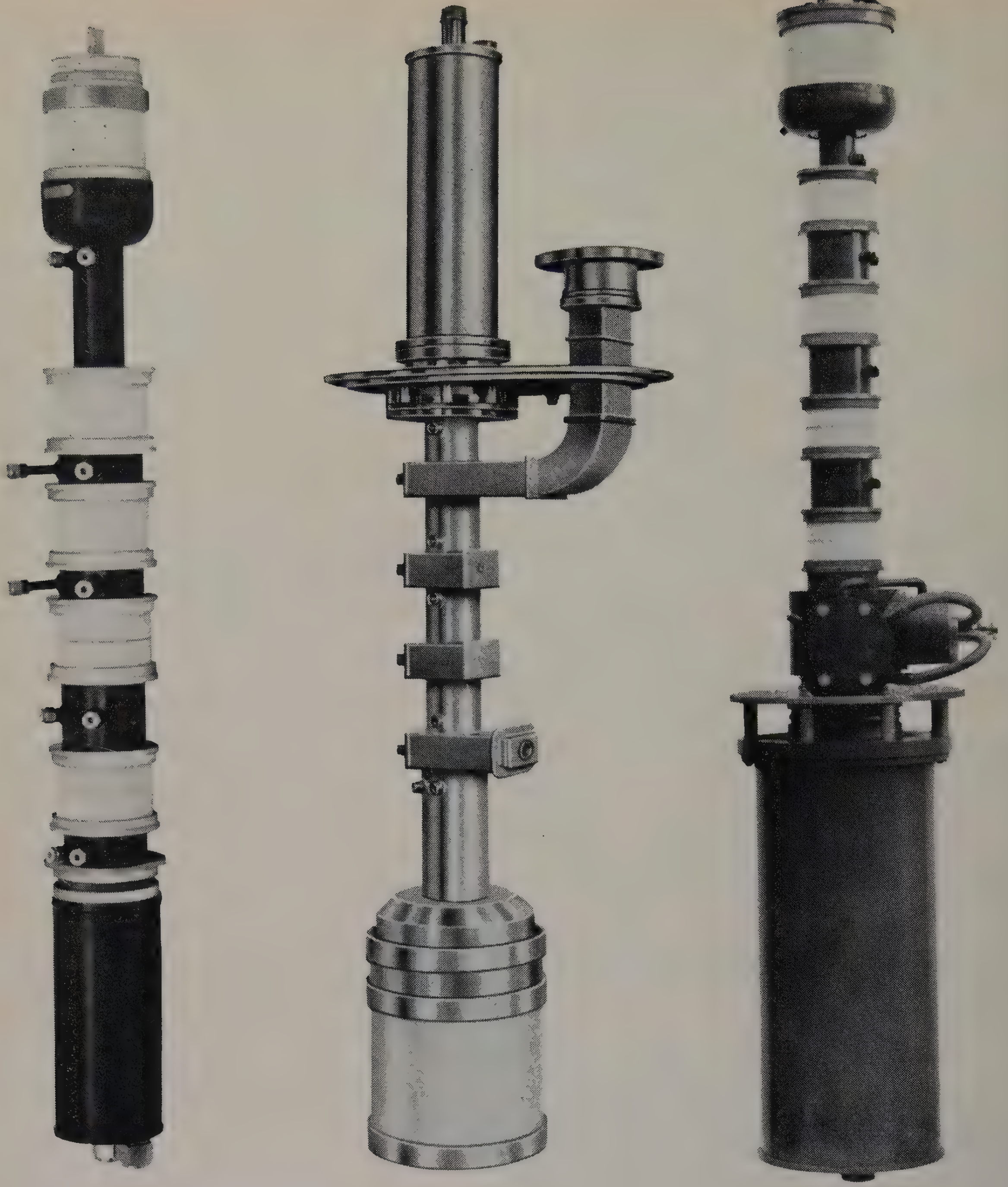

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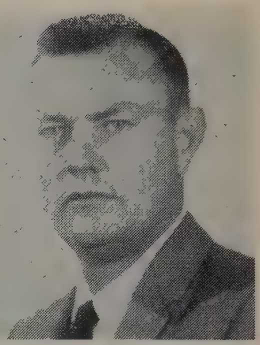

NNETH G. EAKIN was born May 21, 1920, in Port Netches, Texas. He received his BSRE ee from Tri-State College in 1941. In that same year, he entered the Army Signal Corps as nd Lt. under the Electronics Training Program where he was sent to England to attend ar and VHF Communications Schools. He served with the 8th and 12th Air Force as Signal ps Communications Officer from 1942-1944.

Released from active duty in 1945, he joined Lavoie Lab for a few months prior to re- ing a Civil Service appointment with Watson Lab (USAF), Red Bank, N. J. From 1946-) he was with Watson Lab, transferring with Lab to form Rome Air Development Center AF) at Rome, New York in 1950-1960. At R. A. D. C. he held the following positions: ect engineer, Radar Receiver and Microwave Duplexer Development; section and branch f — Antenna and Microwave Component Development; associate member of the Advisory up on Electron Tubes (D. O. D.), and Air Force deputy member of the Working Group microwave tubes.

In May 1960, he joined the Federal Aviation Agency as a task manager at N. A. F. E. C., ntic City, N. J. He is a senior member of the IRE and is a member of the IRE Professional up on Microwave Theory and Techniques.

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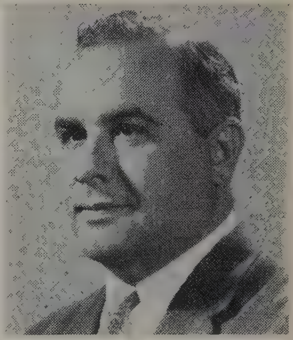
Mr. Hatcher was employed from June to September, 1955 through 1958 by Convair, San go Division, in the Ground Support Equipment and Antenna Research groups. He is presently loyed as a project engineer at Chu Associates, Littleton, Mass.



BERT A. RAPUANO received a BS degree from Yale in 1943 and an SM degree from M.I.T. 947, both in physics. During the war he was a staff member of Radiation Laboratory in the Microwave Test Equipment Group. From 1945 to 1948 he carried out research work in asonics at M. I. T.'s Research Laboratory of Electronics.

His industrial experience was derived at LFE (1948-1950), Raytheon (1951-1959), and mberg-Carlson. At Raytheon he headed a microwave components section and an advanced elopment section for ECM systems. He joined Stromberg-Carlson in 1959, where he is now f engineer of an advanced development department.

His fields of interest are electronic systems, circuits, and microwave component design. Mr. uano is a member of Sigma Xi and RESA.

ROBERT L. THOMAS received his AS degree in Aeronautical Engineering from North Texas Agricultural College, Arlington, Texas, in January, 1943. During World War II, he served with the 35th Photographic Technical Unit, 21st Bomber Command, on Guam, Mariana Islands. At the end of the war, he continued his education at the University of Texas in Austin, and was awarded a BS degree in Electrical Engineering in January, 1950.

Since March, 1950, Mr. Thomas has been employed by the Douglas Aircraft Company, El Segundo Division, as a Design Engineer in the fields of electronic countermeasures and aircraft electrical systems. Recent responsibilities have included microwave antenna design.

Mr. Thomas is a member of Eta Kappa Nu, Tau Beta Pi, IRE - PGMTT and PGAP, Aircraft Historical Society.

JORGEN P. VINDING was born in Copenhagen, Denmark on January 9, 1925. He received his MS degree in electrical engineering in 1950 from the Technical University of Denmark and studied Microwave Technique at Brooklyn Polytechnic Institute during 1951-1952.

From 1950 to 1951 and 1952 to 1954 he was employed by Storno, a Division of Great Northern Telegraph Co. in Copenhagen. In 1954 he joined Cascade Research Corp., Los Gates, Cal., where he worked on microwave application of ferrite and automatic test equipment. In 1957, Mr. Vinding joined Sierra Electronic Corp., Menlo Park, Cal., where he was engaged in the design of microwave test equipment. In November, 1960, he transferred to the IBM Advanced Systems Development Laboratory, San Jose, Cal., where he is presently employed.

He holds four patents and is the author of several technical articles. He is a member of the Institution of Danish Engineers and the American Society of Danish Engineers.

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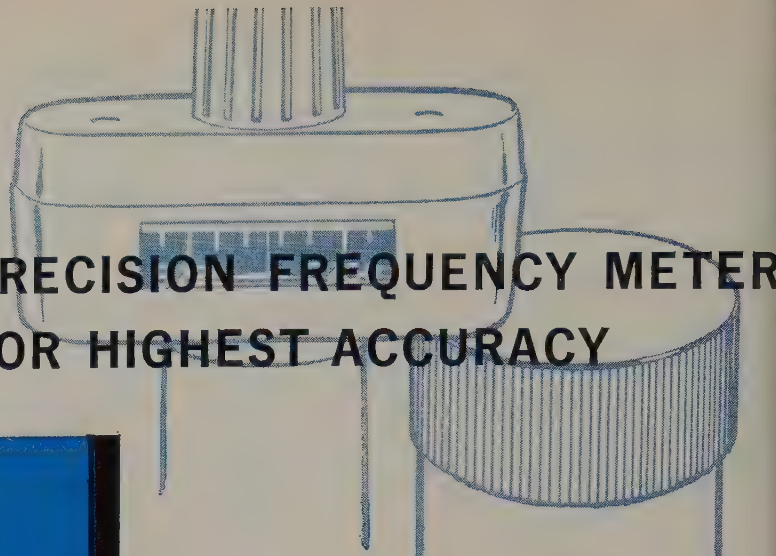

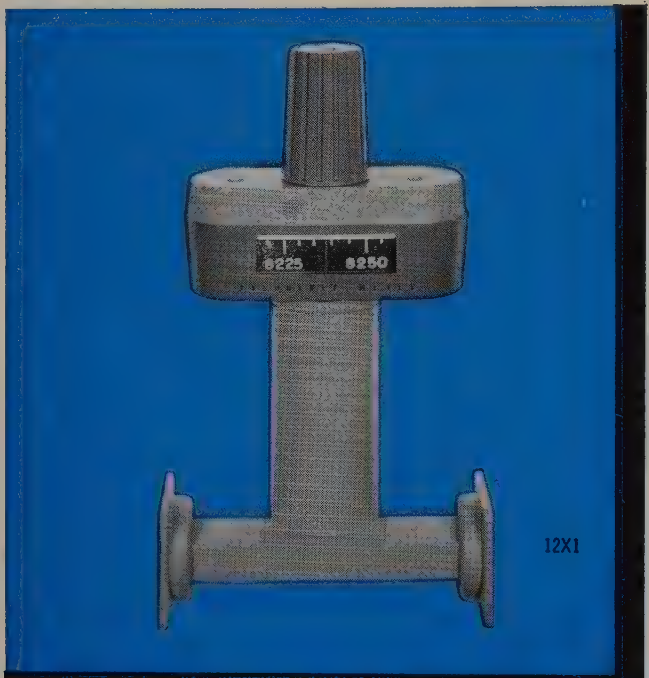

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DESCRIPTION

n most systems applications, it is sufficient to know radiated or available RF power with an accuracy of 0 per cent corresponding to 0.4-0.8 db and this uracy is readily achieved with many types of measur- instruments. For laboratory measurements a better uracy is usually desired, but is frequently not achieved ause the instruments used are inadequate or out of ibration.

n order to make RF power measurements with a con- ent accuracy of about 3 per cent, it is necessary to use truments of a very high stability and to have them ibrated regularly.

It is apparent that recalibration of power meters with per cent accuracy can only be made by com- ison with a primary standard with errors no greater in 0.5-1 per cent, and in measurements of RF power s is equal to, or better than, the best accuracy offered the NBS in routine calibration. It is the purpose of s paper to describe a calorimetric test set which can asure power through a large part of the RF spectrum th a maximum error of ±1.0 per cent ±0.1W and th a response time short enough to be convenient for itine calibration.

Most measurements of RF power with high accuracy based on some variation of the calorimetric princi- :[1, 2] the temperature rise of a known mass during a own time is proportional to the average RF power dur- g this time. The calibration can be made in terms of basic ysical constants, mass, time, temperature, specific heat, by comparison with the temperature rise due to a own energy or power. In each case the mass being ated can be a large thermally isolated mass, solid or quid, or it can be a liquid flowing at a constant rate, in nich case the steady state temperature difference between let and outlet is proportional to the RF power.

An analysis of errors in the various types of calorimeters dicates that the best accuracy can be achieved with a ermally insulated water bath heated by the RF power. ere a limit of error of about 0.5 per cent can be achieved r reasonably high power levels and at most frequencies; it the equipment is unwieldy and the time required r each measurement makes it impractical for most pur- oses; it is also necessary that the RF power stays constant with a high degree of accuracy during the time of a measurement since only the average power over that time can be measured.

The flow type calorimeters are usually many times faster and simpler to operate, but are also subject to many types of errors which do not trouble the other method. Among these the errors due to flow variation and heat leakage out of or into the liquid have often been the most difficult to control.

The equipment described here represents an attempt to achieve the convenience of a liquid flow calorimeter with little or no sacrifice in accuracy. Figure 1 shows the basic components of Model 290 calorimeter: two identical RF terminations (waveguide or coax.) are mounted in an isothermal enclosure and are cooled with equal flows of water from an inlet manifold. The difference in temperature between the outlets from the two terminations is sensed by a differential thermopile and indicated on a sensitive galvanometer.

When a measurement is made, the unknown RF power is dissipated in termination B; the 60 c/s power delivered to termination A is adjusted such that the galvanometer indicates zero temperature difference between the water heated in terminations A and B. Since the two flows are equal, the inlets are fed from a common manifold, and

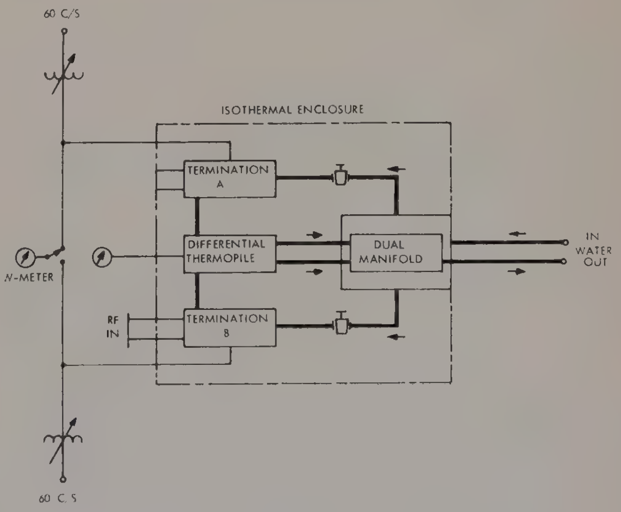

Figure 1 — Balanced calorimeter, principle.

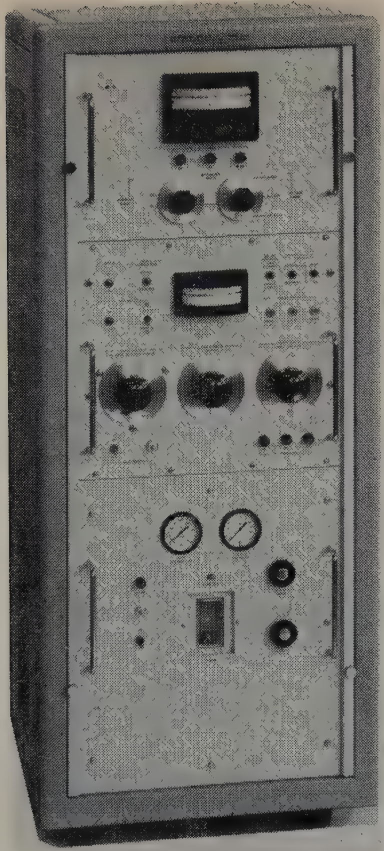

Figure 2 — Model 290B.

the outlet temperatures are equal, the net powers delivered to the water in the two sides must be equal. The 60 c/s power is now measured with an accurate W-meter and after correction for the RF efficiency and RF reflection of termination B, this is considered equal to the RF power.

Before any measurements can be made, it is necessary to balance the flow in the two branches. This is done by applying equal amounts of 60 c/s power to the two terminations while the flow division is adjusted with the two metering valves to give a zero reading on the galvanometer. The powers applied are measured with one W-meter which is switched between the two circuits, and since the W-meter consumes a small amount of power from the circuit in which it is connected, a perfect balance is indicated by equal and opposite galvanometer readings when the W-meter is switched from one circuit to the other. The error introduced in this manner is much less than if two separate W-meters were used since they could not be trusted to be identical.

In the equipment described here the two terminations and the differential thermopile, which have to be close together to avoid heat leakage, form one unit while all other parts of the system are mounted in a cabinet as shown in Figure 2. The two units are connected by a cable and two hoses. In this manner the dual terminations can conveniently be connected to the RF system while the control unit can be used with any one of a series of dual terminations, coaxial or waveguide.

In addition to calibration power supplies and galvanometer circuits, the control unit contains an AC W-meter with 1/4 per cent accuracy and a 2 kw heat exchanger to make the system self-contained for laboratory or field use even where a water supply and drain are not available.

The dual termination contains two identical RF terminations, coaxial or waveguide, mounted symmetrically on heat insulating sections inside a mahogany box with a metal inner liner. The liner is in thermal contact with an aluminum casting which forms the inlet and outlet manifolds so that the whole enclosure will be at a temperature close to the average of inlet and outlet water temperatures. The individual terminations are designed especially for this purpose with emphasis on good heat insulation to the outer cover, rapid heat transfer to the water, high RF efficiency, and very low RF reflection. In the coaxial terminations the same film resistor is used to dissipate either RF or 60 c/s power to ensure exact equivalence; in the waveguide termination the cooling water is the dissipating element for RF while the 60 c/s power is dissipated in a resistor mounted in the water inside the waveguide close to the area where most of the RF power is dissipated.

II. ANALYSIS OF ERRORS

Any measurement is a comparison between a standard and the quantity to be measured, and the accuracy of the measurement is the difference between the true value and the measured value expressed as a percentage of the true value. If this accuracy rating is to have more than local significance, it is necessary that the secondary standard used is traceable to the primary standard maintained by the NBS, and the errors introduced by each step in the sequence of comparison must be added to those introduced by the measurement being evaluated.

In the measuring equipment described here the unknown RF power is compared with an amount of 60 c/s power which can be measured with a W-meter. This W-meter then is the secondary standard through which the measuring accuracy must be traced back to the primary standard of electrical power maintained by the NBS.

The RF power measured as described in Section 1 may differ from the true RF power because the comparison between RF power and 60 c/s power is not perfect and because the value of 60 c/s power measured contains an error. The sources of errors considered are:

1. Imperfect flow division.
2. Imperfect null balance.
3. Contact potentials and stray thermal emf.
4. Friction heating due to water flow.
5. RF efficiency.
6. RF reflection.
7. Heat loss.
8. W-meter error.

Each will be discussed and assigned a maximum value in the following paragraphs.

1. Flow Division

The total rate of water flow does not directly affect the comparison of the RF power and 60 c/s power as long as it is divided evenly between the two branches. The flow division is adjusted with the two metering valves, and if reasonably high 60 c/s powers are used for the adjustment the flows can readily be set equal within 0.1 per cent. The flow division is slightly affected by total flow as shown in Figure 3, and it can also be expected to vary slightly with temperature and maybe with time. The total flow is controlled to ± three per cent and if the flow division is repeated once or twice a day it can be expected to stay stant within 0.1 per cent of its initial setting. There- e the maximum total error due to imperfect flow divi- n is 0.2 per cent.

Null Balance

The null balance setting is limited by the sensitivity the galvanometer, the conversion factor of the differen- thermopile, and the rate of water flow. Actual mea- ements indicate that 0.1 W difference between power sipated in terminations A and B gives a perceptible iation of the galvanometer at the lowest water flow e. The corresponding values for the higher flow rates, ich are only used for high power measurements, are 5 W and 0.5 W.

Contact Potentials and Thermal emf

These spurious electromotive forces are held quite low ough careful choice of materials and they have never en found to cause a perceptible deflection of the gal- nometer.

Friction Heating Due To Water Flow

A certain amount of power is used to force a flow of ter from the manifold through the terminations and rmopile. This will be worse at high flow rates and a pical value is 10 PSI pressure drop at 0.5 GPM through ch termination corresponding to about 2 W per side. nce the flows are adjusted to be equal and pressure drop tween inlet and outlet manifolds must be the same for th sides, these heating effects will cancel exactly. If they d not cancel, a galvanometer reading would appear with power applied to either termination, and this does not ppen.

RF Efficiency

It is known that a small part of the RF power is ab- rbed in the walls of the transmission line rather than in e water, and since the water is not in thermal contact ith the walls, most of this power is not included in the easurement.

Computation of the amount of power lost in a length line similar to the active length of a termination vary om about two per cent in waveguide at 8.2 kMc to out 0.5 per cent in coaxial at 4 KMc and becomes gligible below 500 Mc. In the coaxial terminations ed with this system the computed value can be used with reasonable confidence, but for the waveguide terminations it was considered necessary to measure the fraction of the RF power that is absorbed, but not measured in the regular test procedure. The RF power lost in the termination itself is measured by the calorimetric method described in Appendix A, while the loss in the input waveguide and heat barrier can be accurately calculated, or it can be measured by a method described by Lacy and Miller.[3]

The total measured RF loss for a dual X-band termination is shown as a function of frequency in Figure 5a and is believed to be accurate within 10 per cent of its value giving a maximum uncertainty of 0.2 per cent. The uncertainty in the correction factor used for the dual coaxial termination is estimated as 0.1 per cent.

6. RF Reflection

If the quantity to be measured with the calorimeter is the absorbed power, then RF reflection due to impedance mismatch can of course not produce an error. If, however, the incident power is of interest, any reflection will cause the calorimeter to read too low.

In the waveguide terminations the limit of mismatch is VSWR = 1.10 and a typical value is VSWR = 1.05 corresponding to reflection loss of 0.23 per cent and 0.07 per cent respectively as shown on Figure 7. If a correction factor corresponding to the known VSWR is applied the total error becomes much less than 0.1 per cent. If a standard correction of 0.1 per cent is applied, the total error cannot exceed 0.1 per cent.

In the coaxial termination, the mismatch can be as high as VSWR = 1.20 corresponding to 0.83 per cent reflection loss so a correction should always be applied. When that is done the error due to RF reflection cannot exceed 0.2 per cent.

When a mismatched termination is connected through a length of transmission line to a mismatched generator, it will not only reflect a part of the incident power but will also have a significant influence on the magnitude of the incident power, depending on the phase of the reflected signal, and if the transmission line is many wavelengths long this effect becomes markedly frequency sensitive.[4]

This influence has not been included among the errors of the calorimeter since it can be directly measured or it can be prevented with a system of amplitude stabilization.[5]

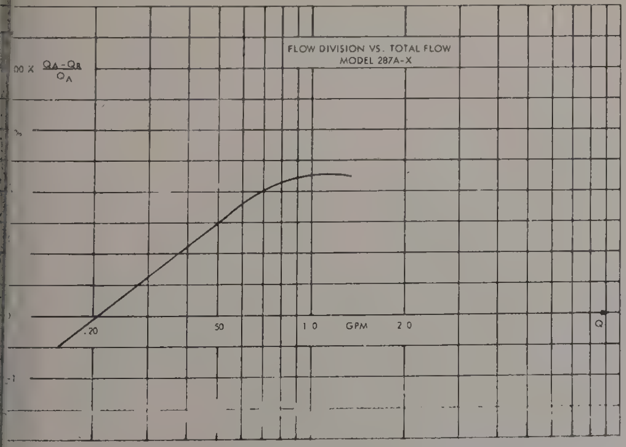

Figure 3 — Flow Division vs. Total Flow, 287A-X.

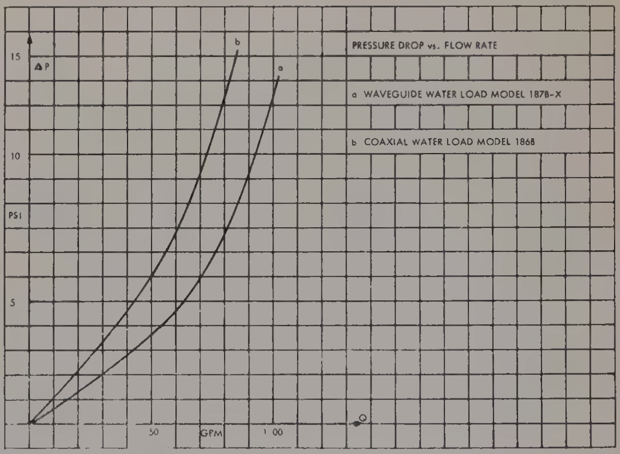

Figure 4 — Pressure drop vs. flow rate for 186B and 187B-X.

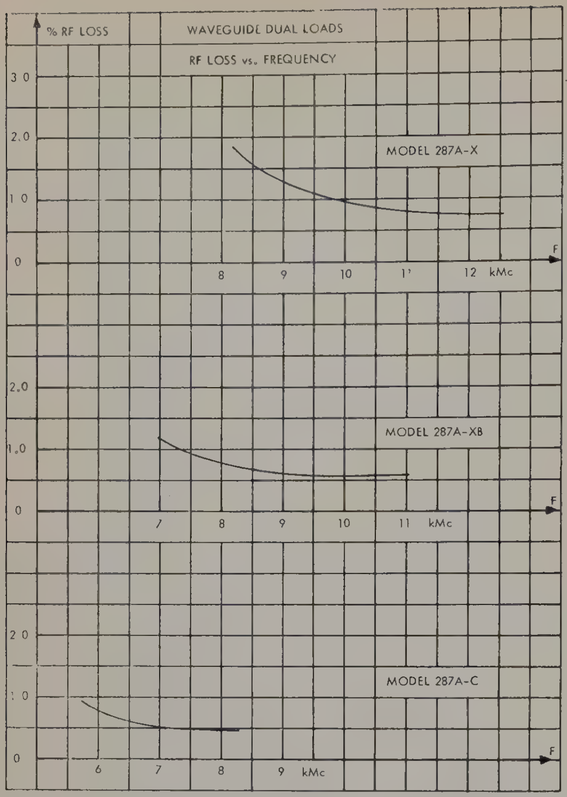

Figure 5a — RF loss vs. frequency for waveguide dual loads.

7. Heat Loss

The heat conductance representing loss of heat from the water to the surroundings was measured in the dual waveguide termination and was found to be less than 0.1 per cent in each load ($G_1 = 30.9$, $G_3 = .026$, see Appendix A), and to be balanced within one per cent of its value so that no error can be caused.

In the coaxial dual termination the heat leakage has not been measured but is expected to be higher than in the waveguide termination. However, there is no reason to expect an unbalance worse than the one per cent found in the waveguide termination, so that no error in measurement is expected.

8. W-meter Error

The W-meter used in the present equipment has a maximum error of 0.25 per cent of full scale and has

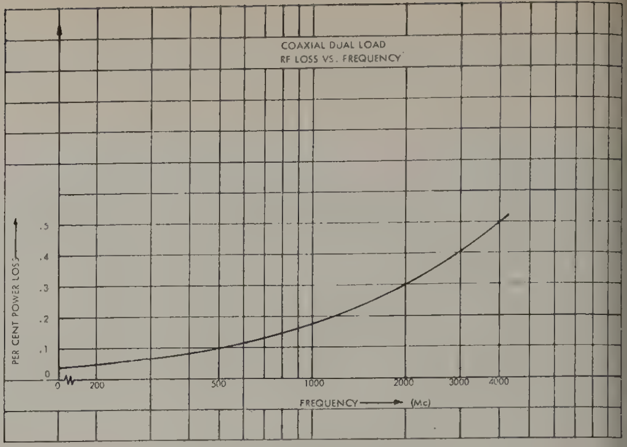

Figure 5b — RF loss vs. frequency for coaxial dual load.

ranges of 50, 100, 125, 250, 500, 1000 W full scale so that with proper use the error cannot exceed 0.5 per cent. This includes errors due to harmonic content of the power supply up to 800 c/s and power factor of the load down to 50 per cent.

The errors discussed are supposed to be the only significant ones in the calorimeter described here. The limit of error can then be found by adding the maximum values:

	Waveguide	*Coaxial*
1. Flow Division	0.2%	0.2%
2. Null	0.1 W	0.1 W
3. Contact Potentials	0	0
4. Friction	0	0
5. RF Efficiency	0.2%	0.1%
6. RF Reflection	0.1%	0.2%
7. Heat Loss	0	0
8. W-meter	0.5%	0.5%
TOTAL	1.0% +0.1W	1.0% +0.1W

It is of course unlikely that all these independent errors would simultaneously have their maximum value and all be to the same side; therefore, the RMS probable error defined as the square root of the sum of the squares of the individual errors gives a more realistic evaluation of the accuracy that can be attained. If the full W-meter error is taken as one item in this calculation the probable error becomes ± .65 per cent at a power level of 30 W where the null balance error is worst.

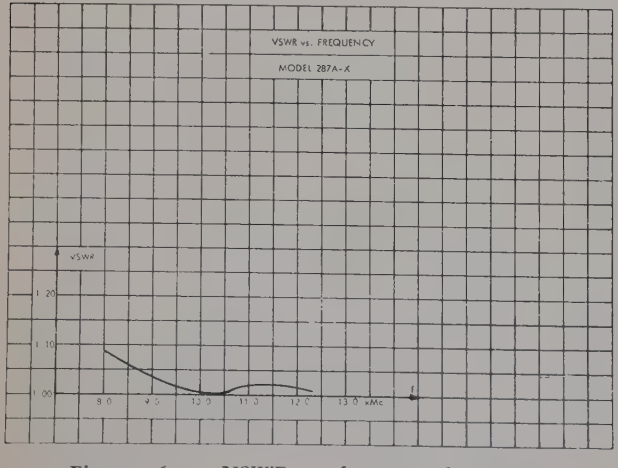

Figure 6a — VSWR vs. frequency for 287A-X.

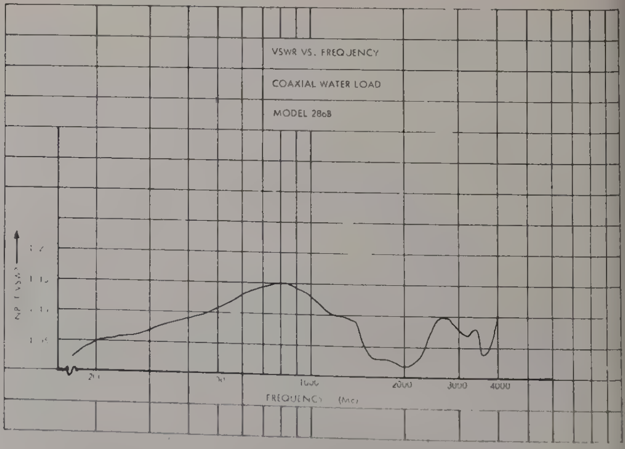

Figure 6b — VSWR vs. frequency for 286A.

The network shown in Figure 8 is a reasonable ap-oximation of the heat conductance paths where points and B represent the water columns in terminations A d B, each considered as an isothermal, although this is t strictly true. Points A′ and B′ represent the waveide bodies, also considered as isothermals, and the comon terminal represents the isothermal enclosure to which e temperature of the other points are referenced. The nperature difference $T_1 = T_A - T_B$ between A and B measured by the regular thermopile and temperature fference $T_O = T'_A - T'_B$ between points A′ and B′ is easured with an additional thermopile installed temrarily between the two waveguide bodies. The conducnces G_{1A} and G_{1B} represent the cooling effect of the ter flows, and all the other heat conductances represent at leakage paths between the waveguides and various ints in the network.

RF power is normally applied to point B and incintally to point B′ through the loss which is to be meared. 60 c/s power is applied to point A.

The network of course includes heat capacity as well as at conductance, but this can be ignored if only steady ate conditions are considered. These are given by four uations:

$$(1) \qquad P_B - T_B G_{1B} - (T_B - T_B') \, G_{2B} = 0$$

$$(2) \qquad P_B' + (T_B - T_B') \, G_{2B} - T_B' G_{3B} - (T_B' - T_A') \, G_o = 0$$

$$(3) \qquad (T_B' - T_A') \, G_0 - T_A' G_{3A} + (T_A - T_A') \, G_{2A} = 0$$

$$(4) \qquad P_A - (T_A - T_A') \, G_{2A} - T_A \, G_{1A} = 0$$

where P_A and T_A represent power input and temperature of point A and similarly for the other points.

In the actual equipment the water flows are adjusted so that $G_{1A} = G_{1B} = G_1$ and since the whole structure is built symmetrically, it is reasonable to assume that $G_{2A} = G_{2B} = G_2$ and $G_{3A} = G_{3B} = G_3$. This is also confirmed by experiments.

As a further simplification of the equations it is assumed that G_2 G_3 and G_o are all much smaller than G_1 so that Equations 1 and 4 reduce to:

$$(1) \qquad T_B = \frac{P_B}{G_1}$$

$$(4) \qquad T_A = \frac{P_A}{G_1}$$

The two measured temperature differences T_1 and T_o can now be found from the four simplified equations.

$$(5) \qquad T_1 = T_A - T_B = \frac{P_A - P_B}{G_1}$$

$$(6) \qquad T_o = T_A' - T_B' = \frac{\frac{G_2}{G_1} (P_A - P_B) - P_B'}{2G_o + G_2 + G_3} = \frac{G_2 T_1 - P_B'}{2G_o + G_2 + G_3}$$

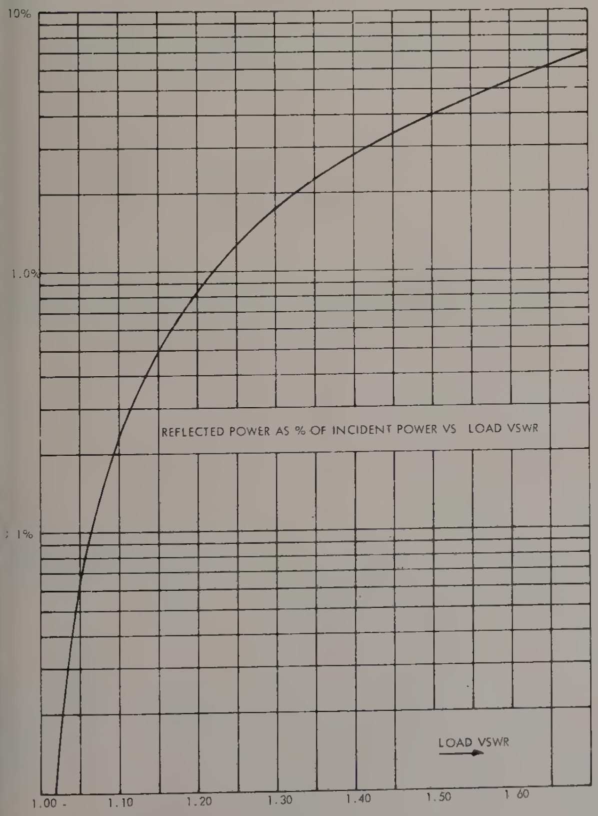

Figure 7 — Reflection loss vs. VSWR.

and if the values of G_o G_2 and G_3 are known, the last power P_B' can be found from measurements of T_1 and T_o.

For the actual measurement the calorimeter is balanced so that $P_A = P_B$ and

$$(7) \qquad P_B' = -T_o(2G_o + G_2 + G_3)$$

Here T_o is negative because load B is warmer than load A.

The heat conductance values of the network in Figure 8

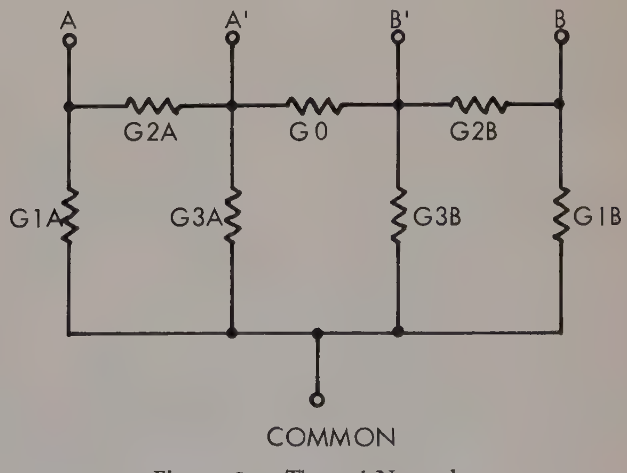

Figure 8 — Thermal Network.

can be determined from three sets of measurements with the same two thermopiles.

a) if $P_B = P_B' = 0$ then

$$(8) \qquad G_1 = \frac{P_A}{T_1}$$

$$(9) \qquad G_a = \frac{P_A}{T_o} = G_1 \frac{2G_o + G_2 + G_3}{G_2} = G_1 \frac{G_2 + (2G_o + G_3)}{G_2}$$

b) Shut off water flow so that $G_{1A} = G_{1B} = 0$

If now $P_B = P_B' = 0$ then

$$10) \qquad G_b = \frac{P_A}{T_o} = 2G_o + G_3$$

c) Shut off water flow in Load B only so that $G_{1A} = 2G_1$ $G_{1B} = 0$

If now $P_B = P_B' = 0$ then

$$(11) \quad G_c = \frac{P_A}{T_o} = 2G_1 \frac{G_o G_2 + 2G_o G_3 + G_2 G_3 + G_3^2}{G_2 G_3}$$

$$G_c = 2G_1 \left[\frac{G_o}{G_3} + \frac{2G_o + G_2 + G_3}{G_2} \right]$$

From these four equations, G_o, G_1, G_2 and G_3 can be found when G_a, G_b and G_c are determined by experiments.

Equation 7 gives G_1 directly from measurements.

Equations 9 and 10 are combined to give

$$(12) \qquad G_2 = \frac{G_1 G_b}{G_a - G_1}$$

Equations 9 and 11 are combined to give

$$(13) \qquad G_c = 2G_1 \left[\frac{G_o}{G_3} + \frac{G_a}{G_1} \right]$$

Equations 10 and 13 can now be solved for G_3

$$(14) \qquad G_3 = \frac{G_1 G_b}{G_c + G_1 - 2G_a}$$

Finally G_o can be found from Equation 10.

$$(15) \qquad G_o = 1/2(G_b - G_3) = 1/2 \left[G_b - \frac{G_1 G_b}{G_c + G_1 - 2G_a} \right]$$

Data on an early model of an X-band dual load are as follows:

Total water flow approx. 0.2 GPM

$G_1 = 30.9$	W/°C
$G_o = .081$	W/°C
$G_2 = .119$	W/°C
$G_3 = .026$	W/°C

The measured deviation from perfect symmetry was never more than one per cent and it is seen that G_1 is more than 200 times any of the other conductances so that both of the simplifying assumptions are justified.

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3. An Improved Method For Measuring Losses in Short Waveguide Lengths, P. D. Lacy and K. E. Miller, Hewlett-Packard Journal, Nov.-Dec., 1957.
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5. Amplitude Stabilization of a Microwave Signal Source, G. F. Engen, IRE Transactions MTT, Vol. 6, April 1958, p. 202.

A HYBRID DUPLEXER*

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INTRODUCTION

A. Function of Duplexers

Klystrons or space-charge amplifiers such as triodes, when used in the transmitter output of a single-antenna radar, can accomplish duplexing by using switches of comparatively low power handling ability. This is possible because of certain nonreciprocal and nonlinear characteristics of these tubes when they are properly designed.

A duplexer must accomplish two things: it must connect the transmitter or the receiver to the antenna with negligible loss, and it must protect the receiver from the transmitter power. These functions are usually performed by gas-filled switching tubes which shunt the transmitter power past the receiver during the transmit period, and channel the received energy into the receiver at other times. Figure 1 illustrates two types of duplexers: branched and balanced.

DISCUSSION

A. Distribution of Amplitude Energy

The tubes in a branched duplexer must switch the full line current resulting from the transmitter at a point which can equal the sum of the incident and reflected currents at the antenna. The current switched by balanced duplexer tubes is 1.4 times this amount. The TR tubes used must also have excellent isolation between input and output, so that the high line current at the input will not result in damage to the receiver. The balanced duplexer reduces this isolation requirement somewhat because of cancellation, but at the price of higher current in each tube.

However, if the transmitter output stage can be composed of klystron or space-charge amplifiers, then the switching function can be left to the amplifiers themselves, while gas-tube (or other) types of switching are used only to protect the receiver.

In order to be satisfactory for this purpose, the amplifiers must have the following properties:

- Phase shifts equal, or capable of being made equal,
- amplitude of ouput equal,
- equal tank reflections coefficient (amplitude and phase) of the output.

Figure 2 illustrates an amplifier stage made up of two amplifiers and their associated circuitry.

The signal from a driver is fed into the "even" arm of a Magic T and to the amplifiers is fed to a second difference. The output of the amplifiers is fed to a second Magic T after another phase difference is added. The resulting signal at the second Magic T is then "even" again, and it couples out of the "even" arm to the antenna, provided the phase shifts in each klystron are the same. Residual amplitude and phase unbalance cause some energy to be coupled to the "odd" (or receiver) arm, but this can be kept to a minimum. Received energy splits equally to each amplifier, but after reflection from the output circuit one portion arrives at the hybrid 180° out of phase with respect to the other. The energy is then coupled to the receiver arm. Antenna reflection as well as transmitter unbalance is also coupled to the "odd" arm but this energy is controlled by the TR tube.

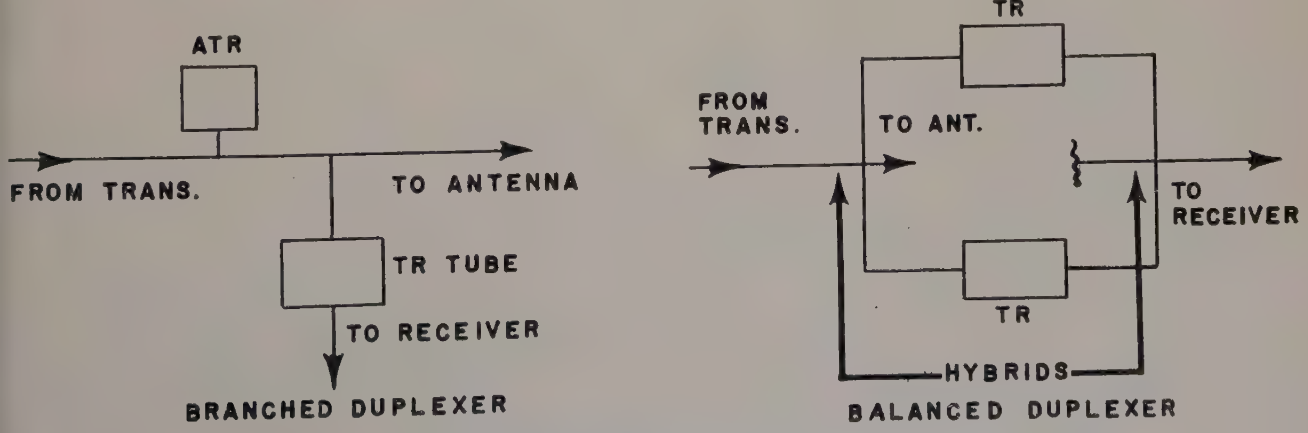

Figure 1 — Types of duplexers.

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* *Released — April 23, 1956. Proprietary rights to the information contained in this report are vested in the Raytheon Manufacturing Company of Wayland, Massachusetts.*

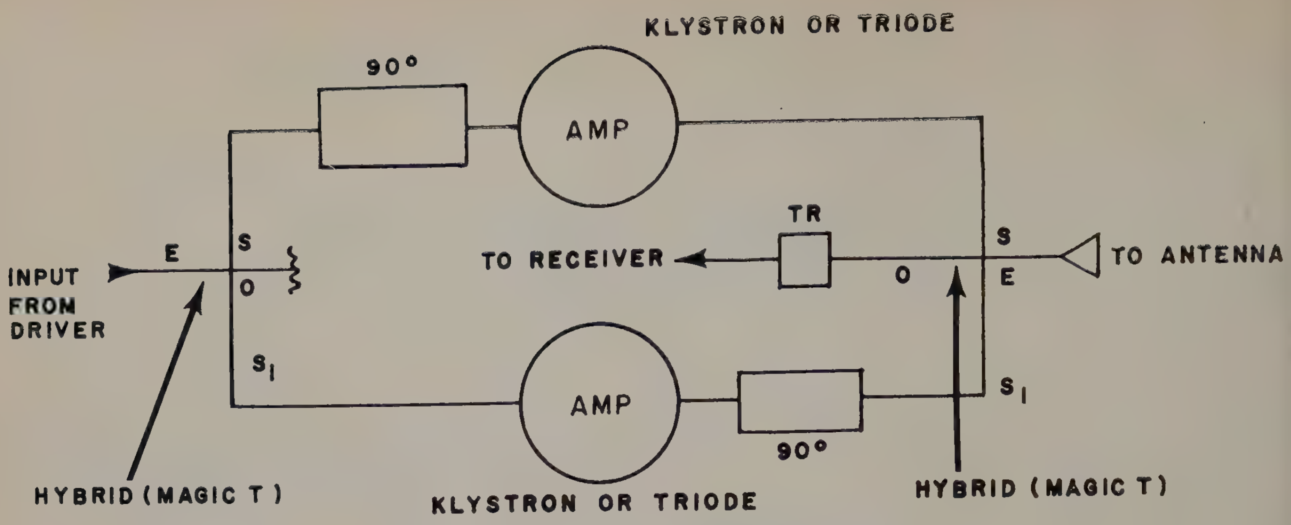

Figure 2 — Amplifier stage with associated circuitry.

B. Phase Shifts and Mismatching

A very satisfactory arrangement is obtained by replacing the Magic T's (Figure 2) with 3-db directional couplers such as Riblet hybrids. These hybrids are characterized by equal power split and a constant 90° phase shift. They introduce far less mismatch into the line than the Magic T's.

The phase shifts through the amplifiers, in klystrons and space charge tubes, are controlled by tube geometry, anode voltage, and resonator tuning. Differential phase shifts between the tubes in a pair will cause power to feed into the receiver arm. Such phase shifts arising from variations in tube geometry can be equalized by placing small trimmers in the input lines. Variations caused by anode voltage fluctuation are equal in both tubes and will cancel if a common anode supply is used. However, resonant circuit tuning can introduce serious differential phase shifts because a mistuning of approximately ten percent of a bandwidth results in a 10° phase shift.

The power coupled to the receiver arm during transmission is also a function of antenna and output transmission line mismatch. If the amplitude and phase of these mismatches are kept constant, the tuneup procedure will cancel the resulting power. Normally there will be some variation of the mismatch as the antenna rotates, which causes a variable residue that cannot be cancelled. The maximum power coupled from antenna line mismatches is then

$$P_u = |T_a|^2 |T_k|^2 P_t,$$

where the T's are the respective reflection coefficients of the antenna line and amplifier tanks. Normal antenna line VSWR mismatch is 1.5 or less, which produces

$$|T_a|^2 = 0.04.$$

T_k can be measured or estimated, and values obtained from known efficiencies or tank parameters indicate that T_k^2 can lie between 0 and 0.5, depending upon the tube design. The power coupled to the receiver arm is thus of the order of two percent and can be much lower. To this value the coupling from mistuning and unequal outputs from each tube must then be added. If a differential phase error of 12° is made during tuneup (i.e., because the tank circuits are not tuned to the same frequency on both tubes), then one percent of the line power is coupled to the receiver. If each tube has a difference in power output of one db, this results in a 0.25 percent contribution to the receiver. The total leakage power is coherent, and in the worst possible (and somewhat unlikely) combination of the values above, the total coupled power may reach 8.4 percent of the main line power. However, if use is made of the proper auxiliary circuitry and tuneup monitors, it is improbable that the coupled power will reach this amount. Thus the receiver protective device need only control less than ten percent of the transmitter output.

This duplexing system can be applied to many more tubes. Each of the amplifiers in Figure 2 can be replaced with a parallel combination of several tubes. Tuneup procedure is quite straightforward, but takes more time because each set of amplifiers must be tuned and balanced separately. In a two-tube arrangement, failure of one of the tubes places one half of the other tube's output in the receiver arm. The TR tube should be able to withstand this load until the transmitter is shut down. An r-f switch is advisable for protecting the duplexer during tuneup.

During the receiving interval the electron stream is cut off and T_k should approach unity. The degree with which T_k approaches unity is determined by the ratio of loaded to unloaded Q of the tank circuit, if the output tank resonant frequency is not changed by the electron beam. At resonance,

$$|T_k| = |1 - 2\frac{Q_L}{Q_O}|.$$

The loss of received signal from this source is

$$L_r = 1 - |T_k|^2.$$

For a typical klystron, $Q_L/Q_O \approx 0.01$, so that $T_k =$ 0.98, and loss of signal is approximately four percent, or 0.2 db. Larger values of Q_L/Q_O can be tolerated if the electron beam causes any appreciable shift of the output tank resonant frequency. The reflection coefficient of the tank in the "receive" condition will not correspond to the resonance value, but to some value which can be several times as great. Reflection coefficient amplitude differences

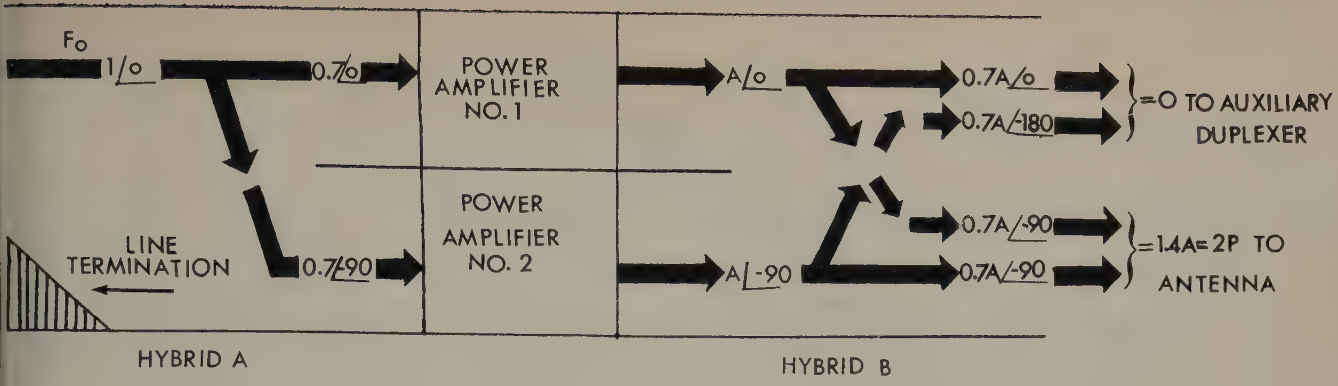
F₀
1/0
0.7/0
LINE TERMINATION
0.7/-90
HYBRID A
POWER AMPLIFIER NO. 1
POWER AMPLIFIER NO. 2
A/0
A/-90
0.7A/0
0.7A/-180
=O TO AUXILIARY DUPLEXER
0.7A/-90
0.7A/-90
=1.4A=2P TO ANTENNA
HYBRID B

Figure 3 — Electric-vector relationships during transmission for the Riblet short slot hybrid.

re unlikely, but if one tube $T_k = 0.98$, and the other is .0, there is a loss of 0.01 percent. Errors of 10° in output uning also result in less than one percent loss, thus the major loss arises from a tank T_k which is less than unity. T_k is normally sufficiently close to this value for satisfactory reception.

C. Operation of Duplexer with Riblet Hybrids

A complete high power duplexer using Riblet* Hybrids is shown in Figures 3 and 4.

The output from a low level driver (F_0) enters hybrid A where the hybrid's action splits it and provides a quadrature phase relation at the inputs of power amplifiers 1 and 2. The signals are amplified without relative phase change and are combined in hybrid B and transmitted. Echoes received from the antenna in the interpulse period enter hybrid B where, by the same hybrid action, they divide and are reflected by the power amplifier plate tank circuits without relative phase change. The echoes then pass into the auxiliary duplexer and on to the receiver, for detection.

The auxiliary duplexer provides the necessary match for proper power split by hybrid B, and it presents a matched load in both the fired and unfired conditions. The matched input in these conditions is a normal characteristic of the short slot hybrid duplexer. Figure 2 shows that a signal entering the duplexer from hybrid B into leg 1 of hybrid C (in the fired condition) is terminated by the load on leg 2. The input signal adds (in the unfired condition), as indicated by the electric vector relationships, and is terminated by a matched receiver.

CONCLUSIONS

A method of utilizing r-f amplifiers in combination with microwave hybrids to extend the power handling capacity of duplexers has been presented. The method will aid materially in reducing the time required to obtain an operational duplexer for use with the ever-increasing radar transmitter powers, and may well dictate the design of high power radar transmitters.

A TR tube can be used with a transmitter power of at least ten times the tube's normal rating, by using the duplexing method described in this report. Receiver loss increase should be 0.2 db or less. Automatic balancing circuits can be developed which will bring about isolations of as much as 30 db.

Acknowledgment

Acknowledgment is made to the Rome Air Development Center, USAF and the Raytheon Manufacturing Company for permission to publish this report.

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*H. J. Riblet, *The Short Slot Hybrid Junction, Pro. I.R.E., pp. 180-84, February, 1952.*

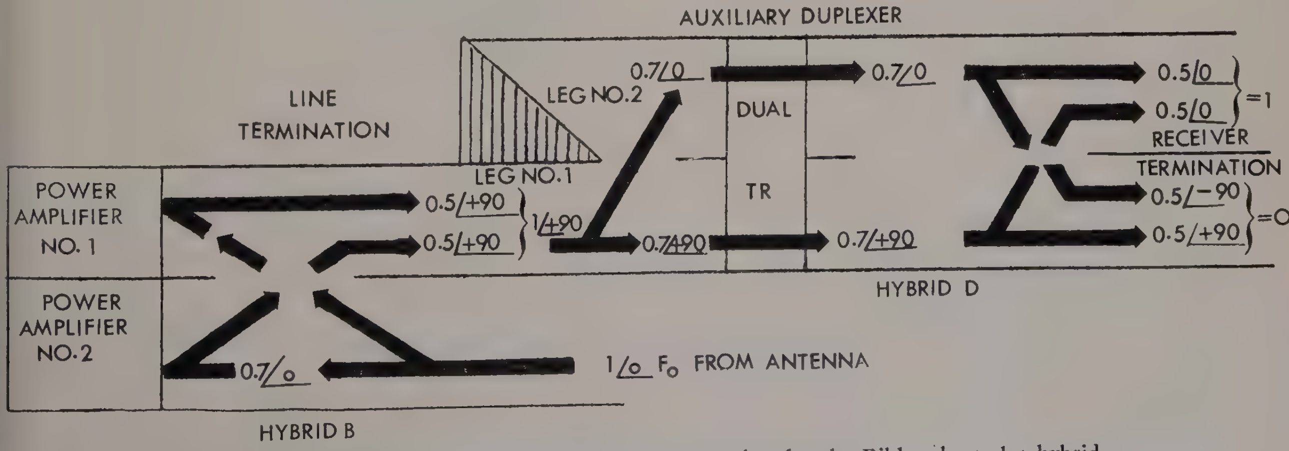
AUXILIARY DUPLEXER
LINE TERMINATION
LEG NO.2
LEG NO.1
0.7/0
0.7/0
DUAL
TR
0.5/0
0.5/0
=1
RECEIVER
TERMINATION
0.5/-90
0.5/+90
=O
POWER AMPLIFIER NO. 1
POWER AMPLIFIER NO. 2
0.5/+90
0.5/+90
1/+90
0.7/+90
0.7/+90
HYBRID D
0.7/0
1/0 F₀ FROM ANTENNA
HYBRID B

Figure 4 — Electric-vector relationships during reception for the Riblet short slot hybrid.

Fundamental Considerations of

MICROWAVE VIDEO DIODES

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Introduction

The crystal-video diode is used quite extensively as a low level detector in the microwave frequency range. At such frequencies, the ordinary type of vacuum tube diode is not usable for detector applications due to its limited response and transit effects. There are other devices, such as bolometers and thermisters, that are also used as detectors in the microwave spectrum, but their sensitivities are not comparable to the crystal diode. These devices possess certain characteristics that are more suitable for low level power monitoring.

A simple receiving system of the crystal-video type is often referred to in military terminology as a CMX receiver (Countermeasures Xtal). CMX receivers, in the past, have demonstrated the capability of detecting pulsed radar signals of peak power levels on the order of 10^{-8} watts (-50dbmw.)[1] at the input of the receiver. These sensitivities were obtainable over such broad r.f. (radio frequency) bandwidths as 50 mcs.-12,000 mcs. Recent developments in microwave crystal holders, antennas, and video diodes have improved the sensitivity and extended the frequency coverage of the CMX receiver. Photographs of two broadband horn-type antenna and detector assemblies, that represent recent progress in this field, are shown in Figure 1. In the lower microwave frequency bands, Haimowitz,[2] has reported the following sensitivities (based on a 2 mcs. receiver bandwidth and with the MA408B diode) in experimental octave coaxial mounts:

Frequency-mcs.	Minimum Detectable Sensitivity — dbmw.
500 - 1000	—59 to —62
1000 - 2000	—62 to —63.5
2000 - 4000	—61.5 to 63.5

The advent of high gain broadband TWT's (traveling-wave-tubes)[3] may, in some cases, provide an additional 25 to 30 db. small signal gain for the crystal-video receiver. This added sensitivity, coupled with the "wide-open"[4] characteristics of the crystal-video receiver shows promise of greatly increased potential capabilities.

Description of the Microwave Diode

Figure 2 shows cross sectional views of several different types of diode constructions — the ceramic cartridg the coaxial, and the coaxial tri-polar. Top views are o the conventional types while the bottom views represen some recent improvements in diode construction. Constructions employed by different manufacturers may var slightly from those internal geometries shown but all ar basically similar.

Cat-Whisker — The cat-whisker (usually tungsten whe the crystal material is silicon) is a very delicate wir whose important properties are its mechanical stabilit

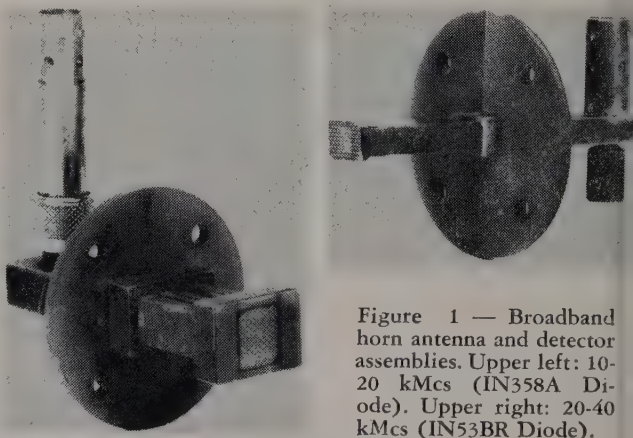
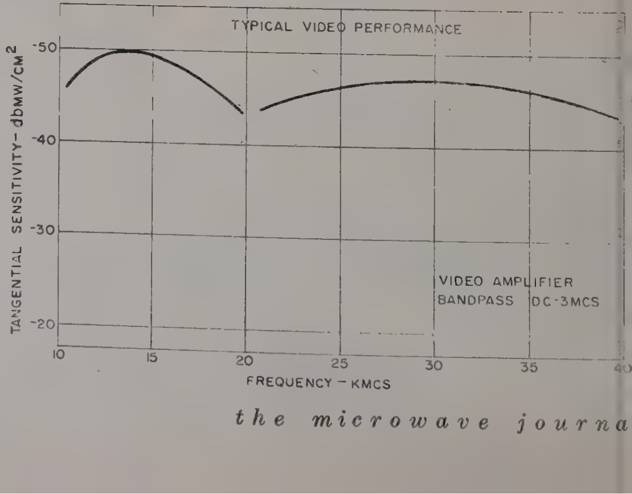


Figure 1 — Broadband horn antenna and detector assemblies. Upper left: 10-20 kMcs (IN358A Diode). Upper right: 20-40 kMcs (IN53BR Diode).



and work function. The importance[5] of the latter property may be somewhat questionable for certain whisker material. The diametric size of the whisker is primarily dependent on the contact forces required and the desired burn-out rating. Sizes vary from 2 mils to 8 mils — the larger diameters being required for high burn-out diodes. The 2 mil whisker has been used for the coaxial type diodes where the whisker space is small and the required contact forces are less. Coaxial types are, therefore, relatively low in burn-out rating and less rugged when compared to the ceramic types. During fabrication, the contacting surfaces of the whisker are given special consideration in respect to shaping and polishing. The conical point appears to be in universal usage with the diameter of the cone on the order of .0001 inches or less.[6] In assembly operations of the cartridge, the contacting force between the whisker and the crystal wafer is adjusted and slightly "tapped" until the low level resistance falls within the video impedance specification for that particular type of diode.

Crystal Wafer — The crystal wafer, usually silicon or germanium, is produced only after undergoing a series of unique controlled manufacturing processes and treatments. Such processes consist of purification, polishing, heat treatment, and etching. The unpolished side of the wafer is plated in order to permit soldering to the mounting in the cartridge. Proper plating is essential to assure good contact between the crystal wafer and cartridge. Poor contact would result in excessive noisiness.

Internal Geometry Aspects — The internal geometry imposes definite limitations on performance for those types shown in the upper views of Figure 2 (conventional types). In the case of the ceramic cartridge crystal, these limitations may be mainly attributed to the non-uniformity of the internal construction. Such a configuration is quite susceptible to pronounced vswr variations and resonance effects as the frequency is varied. Figure 3 is a *theoretical* plot of the variation of admittance with frequency for a video cat-whisker semi-conductor junction. This plot is useful only for noting the extent of vswr spread that one may expect for such broadband operation. The vswr may be reduced somewhat by the application of a small amount of forward d.c. bias to the diode; however, vswrs possibly as great as 8:1 may still be encountered in portions of the band. There are also definite limitations as to the amount of bias that may be used. This will be discussed in the paragraphs describing the effects of bias on diode performance.

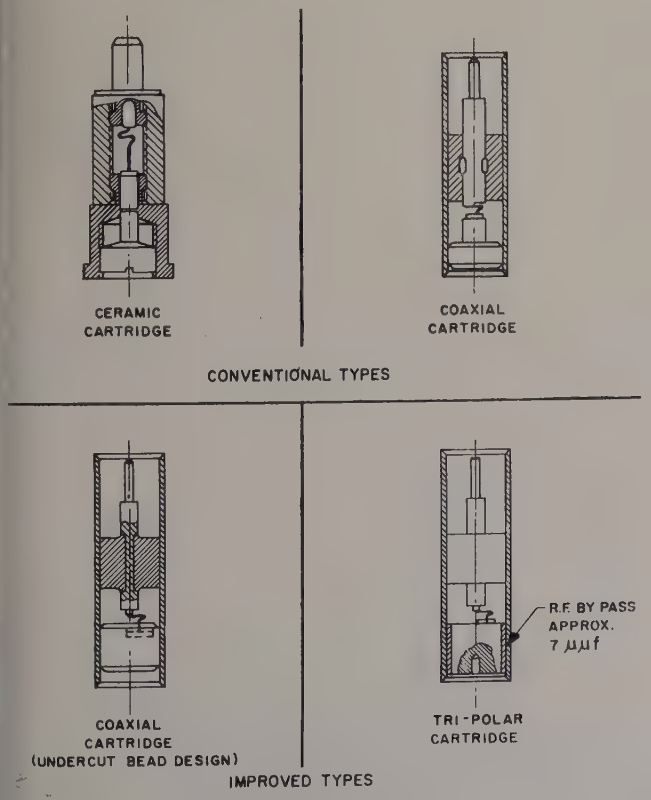


Figure 2 — Cross sectional views of microwave crystal diodes.

The coaxial type limitations arise from the bead that is used to support the center conductor. The center conductor and the case form a 65 ohm transmission line; however, it is evident that the construction does not preserve the 65 ohm "match" in the region where the center conductor projects through the bead. The bead presents a line discontinuity and, at microwave frequencies, reflections are set up with resultant vswr magnitudes dependent upon the dielectric constant and length of the bead cut.[7] These reflections may be minimized at any specific frequency if the length of the bead is cut to be exactly a half wavelength at that frequency. At other frequencies, reflections will be present.

Construction Improvements — Two major design improvements have been incorporated in the coaxial construction — the undercut bead design and the tri-polar construction. These types are illustrated in the lower views of Figure 2. The undercut bead preserves the 65 ohm "match" in the region of the bead and center conductor. Undercut beads are generally not frequency selective and introduce very small reflections over broad r.f. bandwidths.[8] The tri-polar construction provides a video terminal separate from the r.f. terminal and crystal case — hence the tri-polar concept. In addition an r.f. by-pass on the order of 7 $\mu\mu$f. is provided by the isolation of the back plug from the crystal case by a thin layer of dielectric material.

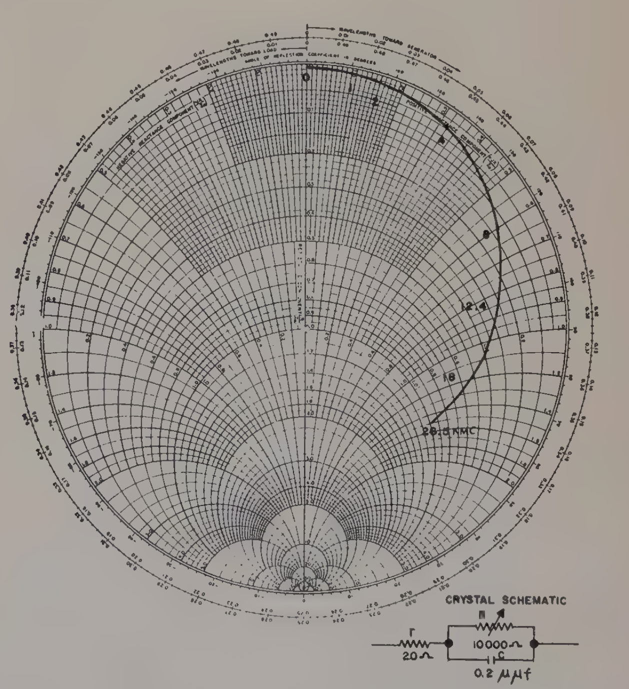


Figure 3 — Admittance plot of a video crystal cat-whisker semiconductor junction (normalized to 65 ohms).

TYPE	DESIGN APPLICATION	DESIGN FREQ.(mc)	IF CONVERSION LOSS	IF IMPEDANCE (ohms)	R.F. IMPEDANCE (VSWR)	BURNOUT RATING (ERGS)	STANDARD TEST HOLDERS
1N21B	Mixer	3060	6.5	250-550		2.0	JAN 124
1N21C	Mixer	3060	5.5	250-550		2.0	JAN 124
1N21D	Mixer	3060	5.0	325-475	1.5	2.0	JAN 124
1N21E	Mixer	3060		350-450	1.3	5.0	JAN 124
1N23B	Mixer	9375	6.5	250-550		1.0	JAN 106
1N23C	Mixer	9375	6.0	325-475	1.5	1.0	JAN 106
1N23D	Mixer	9375	5.0	350-450	1.3	1.0	JAN 106
1N23E	Mixer	9375		335-465	1.3	1.0	JAN 106
1N78	Mixer	16000	7.5	325-625		0.3	JAN 201
1N78A	Mixer	16000	7.0	365-565	1.6	0.3	JAN 201
1N78B	Mixer	16000	6.5	365-565	1.6	0.3	JAN 201
1N26	Mixer	23984	8.5	300-600		0.1	JAN 107
1N26A	Mixer	23984	7.5	300-600		0.3	JAN 107
1N53	Mixer	34860	8.5	400-800	1.6	0.1	JAN 174
1N53A	Mixer	34860	8.5	400-800	1.6	0.3	JAN 174
1N53B	Mixer	34860	6.5	400-800	1.6	0.3	JAN 174
1N286	Broadband Mixer	10-22 kmc	8.5	250-450	3.0	20 mw	Note 1
1N1132	Broadband Mixer	3-12.4 kmc		100-200	2.0	1.0	Note 2

Note 1 - Diode designed for r.f. impedance of 65 ohms.

Note 2 - Mixer in the tri-polar construction.

Figure 4 — Table of commercially available mixer diodes.

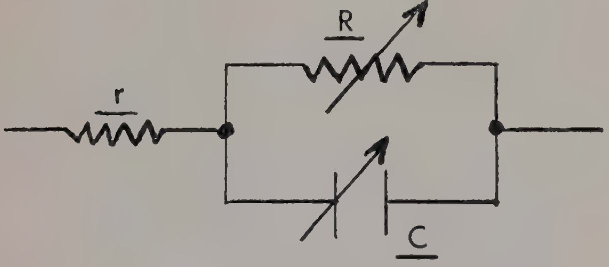
Figures 4 and 5 contain tabulated data of some commercially available microwave diodes. These are partial lists and are only included to indicate typical characteristics. Mixer diodes are included as many of these diodes find popular usage in video detector applications.[9]

Several of the basic types of microwave crystal diodes and their internal geometries have been discussed. It is now appropriate to proceed to examine such crystal parameters as *barrier resistance, barrier capacitance, linear spreading resistance,* and to define the *Figure of Merit* which is the measure of excellence of a crystal video diode.

Crystal Diode Parameters

It is in the region of "square-law" response that the crystal diode finds its application as a low level detector. The exact r.f. input power level where this region commences to exist may vary from crystal to crystal but usually occurs at —20 to —27 dbmw. (2 to 10 μwatts).[10] At r.f. power levels *less* than the above noted values, the rectified crystal output becomes directly proportional to the r.f. power absorbed.

Crystal Schematic — The cat-whisker semi-conductor junction may be represented as shown:



R is the resistance of the barrier at the rectifying junction of the cat-whisker and the crystal wafer. At r.f. input power levels on the order of one milliwatt, the mean value of R is several hundred ohms (silicon crystals) but as the level of input power is reduced, R commences to increase and reaches a fixed value of several thousand ohms[11] when the crystal enters the region of "square law" response. C is the barrier capacitance with values of several tenths of a $\mu\mu$f. r is the linear spreading resistance of the semi-conductor and its magnitude usually varies from 10 to 30 ohms. The crystal parameters may be considered independent of frequency and are not functions of the r.f. input power level in the "square-law" region. These parameters may, therefore, be determined under conditions of low input power levels. Detailed techniques of measurements are described in published articles.[12]

Output Signal To Noise Voltage Ratio of a Video Receiver — The output r.m.s. noise voltage of a crystal-video receiver (when there is no bias applied to the diode) may be expressed as follows:

$$(1) \qquad \overline{N} = G\sqrt{4kTB\ (R+R_A)}$$

where: $\overline{N}$ = r.m.s. noise voltage.
G = video amplifier voltage gain.
k = Boltzmann's constant.
T = effective temperature.
B = receiver effective noise bandwidth.
R = video resistance of the diode.
R_A = equivalent noise generating resistance in series with the grid circuit of the input stage of the amplifier. (defined by JAN crystal-video specifications as 1200 ohms)

The output signal voltage of the crystal-video receiver is given by:

$$(2) \qquad E = \beta PRG$$

where: E = signal voltage.
β = crystal diode current sensitivity.
P = r.f. power absorbed by the diode.
$R, G,$ = as defined in equation (1).

The current sensitivity (β) in equation (2) is an expression of the rectified crystal output current to the input r.f. power absorbed and considers only the rectifica-

TYPE	DESIGN APPLICATION	DESIGN FREQ.(mc)	FIGURE OF MERIT-MIN.	VIDEO IMPEDANCE (ohms)	TANGENTIAL SENS(-dbm) MIN.	BURNOUT (mw)	STANDARD TEST HOLDER
1N358	Broadband Video Detector	1-12.4 kmc	15	4.5-18 k	-40.0*	20	Note 1
1N358A	Broadband Video Detector	1-12.4 kmc	30	4.5-18 k	-45.0*	20	Note 1
1N369	Broadband Video Detector	3-12.4 kmc	15	4.5-18 k	-40.0*	20	Note 1
1N369A	Broadband Video Detector	1-12.4 kmc	15	4.5-18 k	-40.0*	20	Note 1
1N446	Broadband Video Detector	26.5-40 kmc	15	3.0-23 k	-40.0*	20	Note 2
1N630	Broadband Video Detector	1-12.4 kmc	15	4.5-18 k	-40.0*	20	Note 3
1N1610	Broadband Video Detector	3-12.4 kmc	15	4.5-18 k	-40.0*	20	Note 3
1N31	Video Detector	9375 mc	55	6-23 k		20	JAN 118
1N32	Video Detector	3295 mc	85	4-22 k		360	JAN 152
MA408	Video Detector	9000 mc	130	1.7-3.1 k	-50**		MA 611
MA408A	Video Detector	9000 mc	160	1.7-3.1 k	-51**		MA 611
MA408B	Video Detector	9000 mc	220	1.7-3.1 k	-52**		MA 611

Note 1 - These diodes have r.f. impedances designed to match 65Ω. They may therefore be used in broadband coaxial type holders, that provide a transition from the nominal 50Ω to 65Ω. (Such as Sage Laboratories series 101 holders).

Note 2 - Note 1 applies, except that holder must be waveguide. Transition may be waveguide to coaxial.

Note 3 Note 1 applies. These diodes are high temperature units designed to operate up to temperatures of 150°C.

Figure 5 — Table of commercially available video diodes. * Video amplifier bandpass: 7 Mcs.
** Video amplifier bandpass: 10 Mcs.

tion properties of the crystal. This should not be confused with *"detector sensitivity"* which is a measure of the crystal performance in the presence of *noise.* Such expressions as *"Minimum Detectable"* and *"Tangential Sensitivity"* do include the relationship of signal presence in noise level and are, therefore, more meaningful measures of crystal performance. These expressions will be discussed in more detail in later paragraphs devoted to measurement techniques.

The output signal to noise voltage ratio of the receiver may be obtained by dividing equation (2) by (1).

$$(3) \qquad \frac{E}{N} = \frac{P}{\sqrt{4kTB}} \cdot \frac{\beta R}{\sqrt{R + R_A}}$$

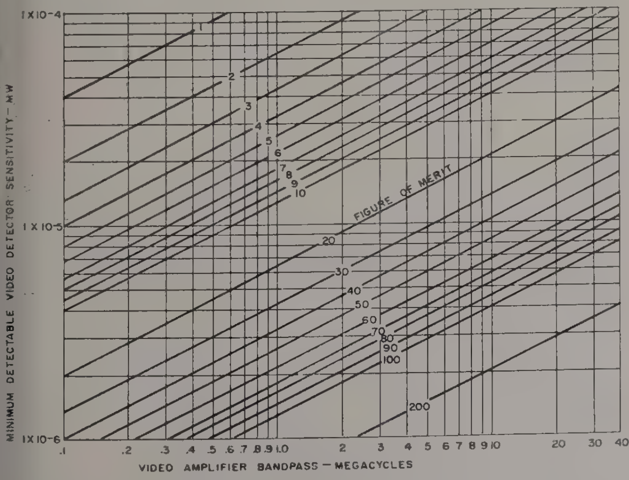


Figure 6 — Figure of merit vs detector sensitivity and video amplifier bandpass.

Figure of Merit — The quantity $\frac{\beta R}{\sqrt{R + R_A}}$ in equation 3 contains all the parameters associated with the crystal diode and may thus be considered as a measure of excellence of a crystal-video diode. This measure of excellence is referred to as the *"Figure of Merit"* and is expressed as follows:

$$(4) \qquad M = \frac{\beta R}{\sqrt{R + R_A}} \text{ Where } M = \text{Figure of Merit.}$$

Equation (4) is valid for d.c. bias equal to zero. If bias is used, R in the denominator must be replaced by $\overline{Rt}$ where t is the noise temperature of the biased crystal for a given video amplifier.

Figure 6 shows the relationship of the Figure of Merit versus video amplifier bandpass and "Minimum Detectable" sensitivity. This curve is useful in obtaining an indication of the expected sensitivity of a video diode (with a known Figure of Merit) for a particular crystal-video system application.

Effects of D.C. Bias

The effects of d.c. bias on the performance of video diodes are indeed interesting and well worth describing in this article. The term "bias" will be defined as *forward* d.c. bias. Negative bias will not be discussed as such bias produces adverse effects on video crystal performance.

Pulse fidelity reception of very narrow pulse width radars (on the order of tenths of a microsecond) and maximum sensitivity are two very important factors in CMX receiver applications. To obtain pulse fidelity, it is

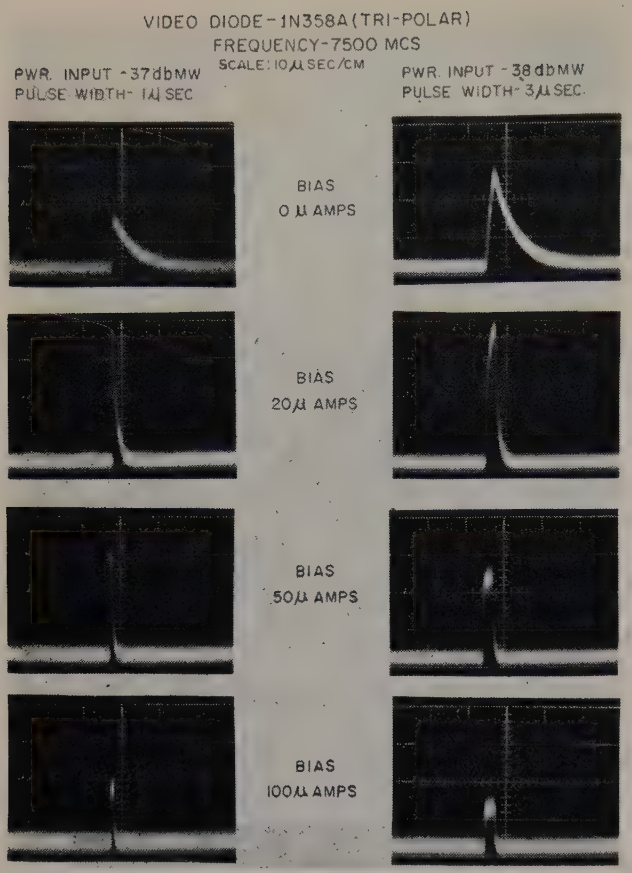


Figure 7 — Effects of forward dc bias.

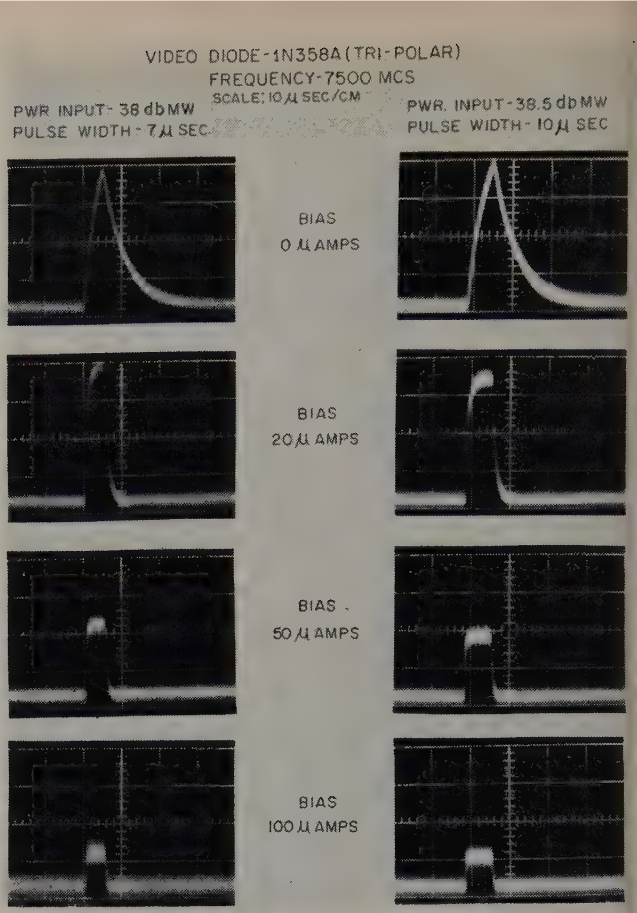


Figure 8 — Effects of forward dc bias.

almost a necessity to resort to the application of bias. The use of bias may or may not improve the system sensitivity. In some cases, a slight loss in system sensitivity may be incurred as a result of bias. The general effects of bias are summarized as follows:

System Sensitivity — It has been previously noted that the value of video impedance of silicon diodes in the region of "square-law" response is several thousand ohms. A small amount of forward d.c. bias applied to the diode will reduce this impedance to several hundred ohms. The system sensitivity may be improved if this reduction of video impedance has provided a better r.f. "match" to the source. Figures 7 and 8 are photographs reflecting the effects of bias on sensitivity and pulse fidelity for various bias levels and pulse widths (the 1N358A tri-polar crystal mounted in a coaxial holder was used in this investigation). It is interesting to note that a significant increase in sensitivity was obtained for the narrow pulse widths investigated (1 and 3 μsecs.) with the proper bias level with relatively little effect on the sensitivity for the larger pulse widths (7 and 10 μsecs.).

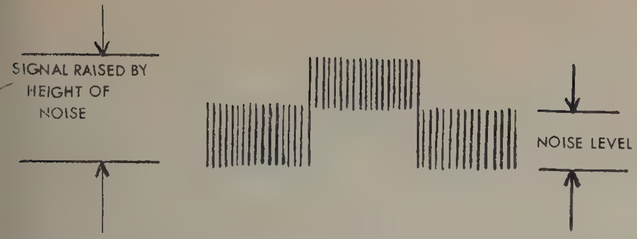
Pulse Fidelity — For r.f. input power levels on the order of one milliwatt, bias will improve the fall time of the received pulse with little change to the rise time. At low r.f. input power levels, however, bias will improve both the rise and fall time characteristics. Photographs in figures 7 and 8 reflect these effects.

Recommended Bias Levels — Recommended bias levels fall in the 10 to 50 microampere range. Usually 20 to 30 microamperes will produce the desired results without a significant loss in system sensitivity. Bias levels greater than about 50 microamperes will generally result in an excessive increase in diode noise level with an accompanying loss in sensitivity that may not be acceptable.

On occasions even the "optimum" bias level will adversely affect some few diodes of the same batch and type. Those diodes adversely affected will display excessive noise level increases with losses in sensitivity of about 3 to 5 db. This behavior is not readily explainable. Recent tests of some improved low noise diodes[14] indicates that crystal manufacturers are making considerable progress in the reduction of the effects of bias on diode noise level.

Some Laboratory Measurement Techniques

Measurement Criteria — Before describing some video diode measurement techniques, it is first necessary to comment on the criteria of measurement that is in common usage today. Such criteria involves the relationship of the detected signal in the presence of the noise level. Perhaps the most widely used measurement levels are the *"Minimum Detectable"* and the *"Tangential."* The Minimum Detectable signal exists when its presence is just barely discernible in the noise. Beringer[15] has determined, experimentally, that measured values of Minimum Detectable signals and calculated values [for $E/\overline{N}=1$ in equation (3)] agree very closely. The Minimum Detectable measurement level is subject to large variations in obtained results, when performed by different operators, due to the difficulty of determining the signal presence in the noise level when its position along the oscilloscope trace is unknown. The Tangential signal level is considered about 4 db. above a Minimum Detectable and may be pictured as follows:



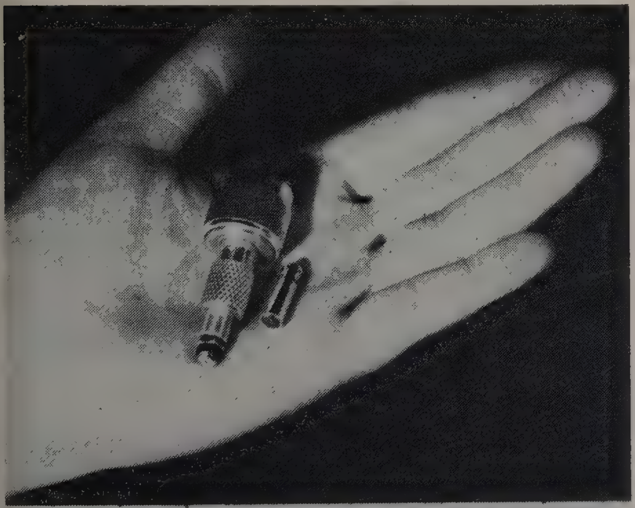
The Tangential signal level measurement lends itself to better repeatibility. It is reported[16] that the absolute level of the Tangential signal is not dependent on repetition rate, pulse width, noise level, or oscilloscope intensity; however, self-consistency appears to depend to some extent on the last factor.

Crystal Holders — There are numerous types of commercial crystal holders available — both coaxial and wave guide and either in the fixed tuned or tunable types. The choice of a particular type of holder will depend on the type of diode to be evaluated and the nature of the test results desired. Photographs in Figures 9 and 10 reflect several types.

Crystal and Holder Sensitivity Measurement — Figure 11 is a typical test set-up that may be used to evaluate the video performance of a crystal and holder (waveguide or coaxial). The measurement procedure consists of first calibrating the signal source at a particular test frequency and transmitting a test signal of chosen pulse width and repetition rate to the crystal and holder. Crystal bias may be applied if such tests are to include the performance of the crystal under bias conditions. The oscilloscope is adjusted for a convenient noise level and the source calibrated attenuator is adjusted until a Tangential signal level appears on the oscilloscope. The amount of attenuation (usually expressed in db. below one milliwatt) noted on the source calibrated attenuator is the sensitivity of the crystal and holder at the particular test frequency. Sensitivities at other frequencies are determined in a like manner.

There are certain precautions that should be observed in performing measurements of this nature. Adequate warm-up time must be allowed for the signal source to stabilize (furnished manufacturers' data will provide the specified time). The signal source must be well "matched." Sufficient attenuation must be preset in the signal source attenuator prior to transmitting the test signal to assure that damage or burn-out of the crystal does not occur.

The bandpass of the video amplifier must be known in order for the obtained test results to be meaningful. This will permit the results to be converted to expected sensitivities when the crystal is to be used with another video amplifier.



BROAD BAND CO-AXIAL VIDEO DIODE AND HOLDER

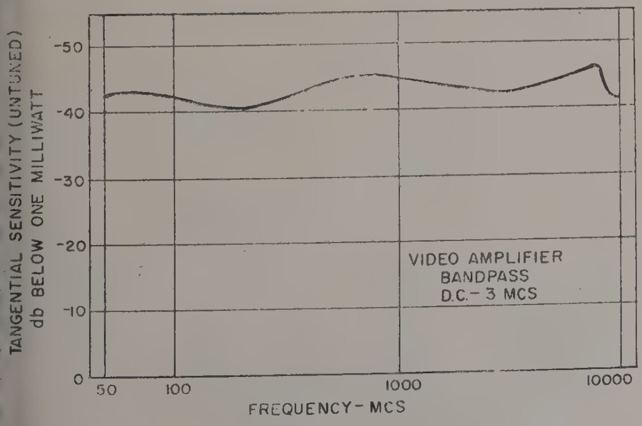
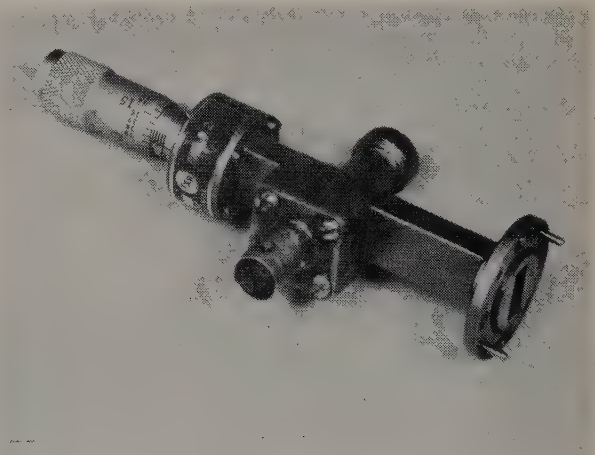
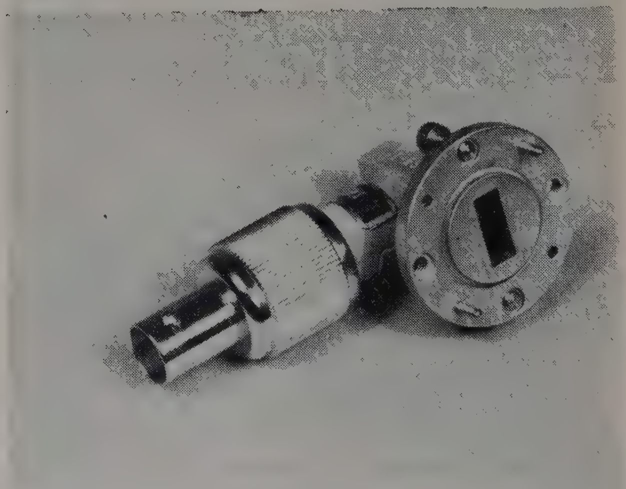


Figure 9



TUNABLE



FIXED TUNED

Figure 10 — Waveguide Crystal Holders.

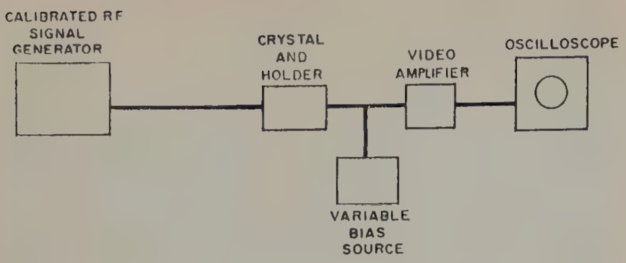


Figure 11 — Test set-up for measuring tangential sensitivity of crystal and holder.

Crystal-Video System Sensitivity Measurements — Figure 12 is a test set-up suitable for the determination of the overall system sensitivity of a crystal-video receiver. Calibration of the signal source and transmitting of the test signal are similar to that previously described. An r.f. tuner is required to "flatten" the transmission line and minimize losses due to mismatch.

The overall system sensitivity may be defined by the following equation:

$$P_D = \frac{Pt \;.\; Gt}{4\pi \;.\; D^2} \qquad (5)$$

where:

P_D = System sensitivity expressed as the power density level existing at the aperture plane of the receiving antenna that produces a Tangential signal level. — — dbmw/cm.^{2}

Pt = Power transmitted — mw.

Gt = Gain of the transmitting antenna-numerical.

D = Distance between the aperture planes of the antennas — cm.

The sensitivity data obtained may be reduced to crystal and holder sensitivity if information concerning the effective aperture[17] of the receiving antenna is known. Measurement techniques of this type involve "free space" transmission of r.f. energy and necessarily require a knowledge of additional factors. Such factors require consideration of test sites, test distances, and the consideration of phase front and amplitude variation effects across the aperture plane of the receiving antenna. It is suggested that the reader refer to suitable antenna texts[18] for more detailed information regarding these factors.

Summary

The internal geometry imposes definite limitations on the video performance of crystal diodes. Recent design improvements, such as the undercut bead and tri-polar construction, have reduced some of these limitations.

It is in the region of "square-law" response that the crystal diode fulfills the role of a low level detector in the microwave frequency spectrum. The crystal parameters are not functions of the input r.f. power in this region and may be determined under conditions of low input r.f. power.

The Figure of Merit is an expression that contains all the parameters associated with the crystal diode and may, therefore, be used as a measure of excellence of video diode performance.

Forward d.c. bias may be used to improve the pulse fidelity reception of narrow pulse width radars. Bias levels in excess of about 50 microamperes will generally result in an increase in diode noise level with a resulting loss in sensitivity.

Video diode sensitivity measurement criteria must involve the relationship of the signal in the noise level. Popular measurement levels in usage are the "Minimum Detectable" and the "Tangential."

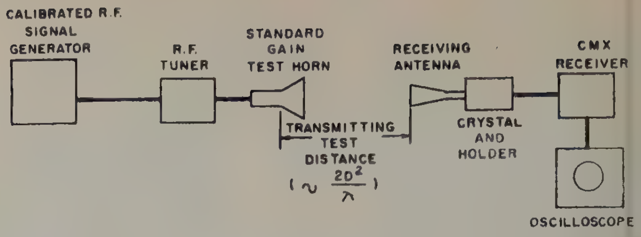


Figure 12 — Test set-up for measuring crystal performance in CMX system (crystal holder integral part of CMX antenna).

Acknowledgments

Much of the background information required for the preparation of this article was obtained from test results of crystal-video systems in the microwave laboratory of the Douglas Aircraft Co., El Segundo Division.

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Appreciation is also expressed to Mr. Jack P. Pacente for his assistance in the many laboratory measurements.

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Survey of
ELECTRONICALLY SCANNED ANTENNAS

HAROLD SHNITKIN
ADVANCED MICROWAVE DEVELOPMENT DEPT.
W. L. MAXSON CORPORATION
New York • New York

LAST OF TWO PARTS

A. Mechanical Phase Shifters

These units are effectively line stretchers or variable delay lines. An example of such a device is illustrated in Figure 12 where extension of the "trombone" section changes phase. Furthermore, as shown in Figure 13, a hybrid junction and two ganged shorting-plungers can be made to serve the same purpose. The distances from each of the plungers to the electrical center of the hybrid differ by a quarter wavelength to prevent the reflections from reaching the input port.

In practice this unit may consist of a short slot hybrid terminated by two equidistant movable shorting planes. Shorting plane designs have been perfected which employ an especially cut dual cam passing centrally through a waveguide, parallel to the E-vector; the cam contour and its velocity will produce a predetermined phasing program (See Reference 10).

Another mechanical phase shifter makes use of the variable delay introduced by any periodic loading structure, such as a filter, whose cut-off frequency is varied. The relationship between the cut-off frequencies (f_{c1} and f_{c2}) to the frequency of operation determines the phase shift. This can be demonstrated by the expression for the phase constant of a band-pass filter

$$\beta = 2 \sin^{-1} \frac{2f - f_{c1} - f_{c2}}{f_{c1} - f_{c2}}$$

The phase shift β is thus a function of the upper cutoff frequency, f_{c2}, which can be controlled by insertion of reactive structures into the transmission line or by altering the inductive loading through a change in permeability (e.g. ferrite).

Other examples of such phase shifters are waveguides

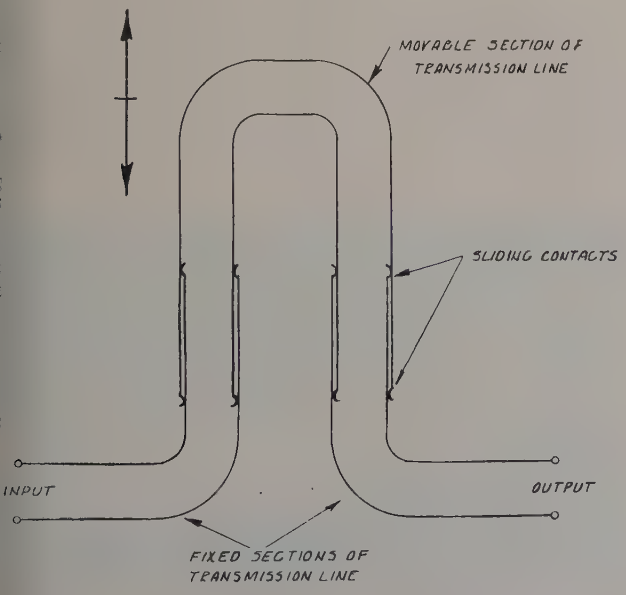

MOVABLE SECTION OF TRANSMISSION LINE
SLIDING CONTACTS
INPUT
OUTPUT
FIXED SECTIONS OF TRANSMISSION LINE

Figure 12 — Trombone-type mechanical phase changer.

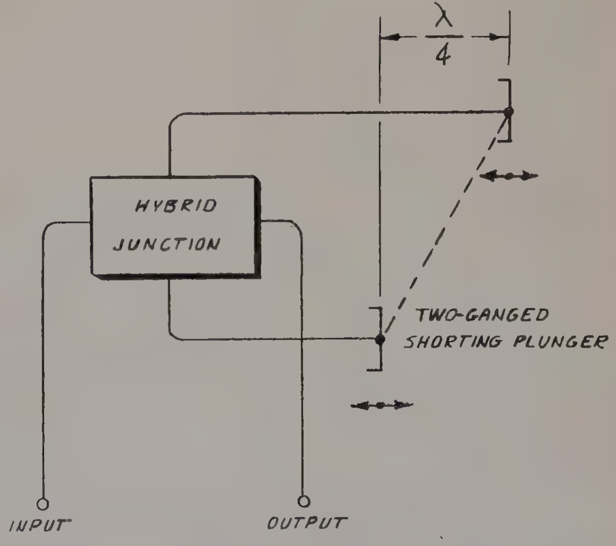
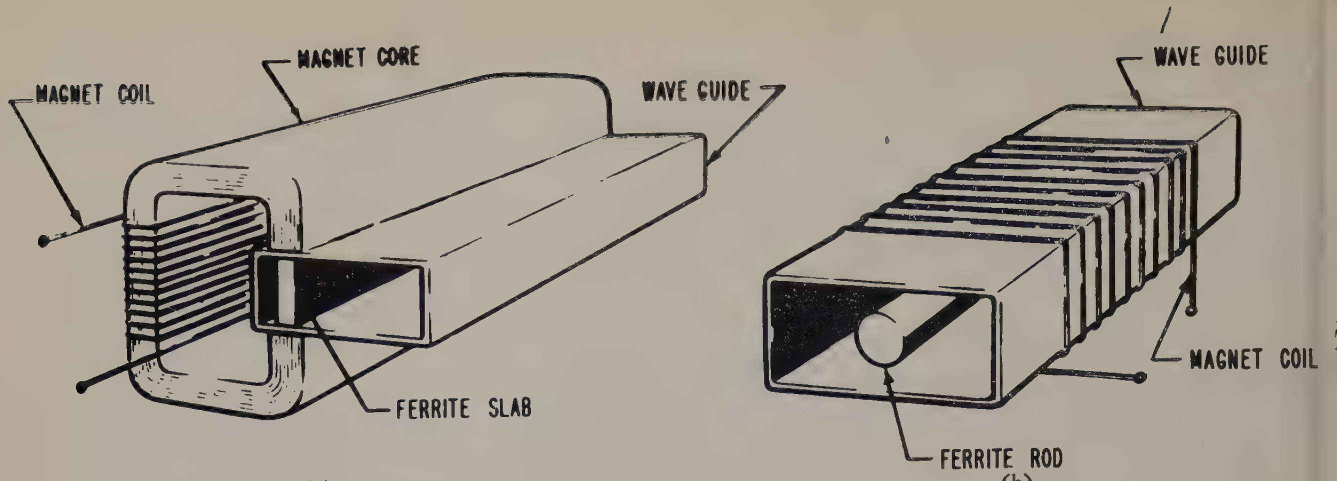


Figure 13 — Hybrid-type mechanical phase changer.



(a) (b)

Figure 14 (a) — Transverse field ferrite phase shifter. (b) — Longitudinal field ferrite phase shifter.

with adjustable width dimension, and transmission lines with variable-depth serrations.

An extremely accurate phase shifter is the Fox phase shifter, which consists of two stationary quarter wave plates, to convert linear polarization to circular polarization, and a 180° differential phase delay section. The latter exhibits a 180° phase difference between two orthogonal polarizations; in effect, it provides a reversal of the sense of circular polarization (See Reference 11). This unit produces two degrees of electrical phase shift for each degree of mechanical rotation; it further offers the advantage of providing continuously variable phase shift.

Another phase shifter utilizing circularly polarized waves was recently reported by R. E. Miller (References 12, 13, 14). It consists of two spiral antennas wound in the same direction and rigidly connected to each other mechanically as well as electrically. Phase shift is produced by the fact that the phase of radiation of a circularly polarized antenna can be controlled by its angular orientation. This system resembles the Fox phase shifter because it requires a circularly polarized input and the two rotating spiral antennas are analogous to the 180° phase delay section.

Most mechanical phase shifters are extremely accurate and suffer least from variations in frequency, temperature, and power level. Their mechanical inertia is considerably less than that of the entire antenna structure, but nevertheless high enough to limit scan rates to about five milliseconds per beamwidth.

B. Ferrite Phase Shifters

This class of devices makes use of the variable RF permeability of ferrite materials, i.e., ceramics prepared from oxides of iron, aluminum, and other metals. The application of a steady magnetic field at right angles to two components of the RF magnetic field is needed to attain this effect in ferrites (Reference 15). The two configurations of this device, usually employed, are the transverse field phase shifter and the longitudinal field phase shifter (Figures 14 and 15). The operation of the former is best explained with the aid of Figure 16. Here the effect of magnetic field changes upon the waveguide mode configuration is depicted. An increase in magnetic field results in lower RF permeability in the ferrite. This lowers the intrinsic impedance of the ferrite and causes the E-field at the interface between air and ferrite to b depressed. The change in mode configuration affects th cut-off frequency, and with it, the phase velocity as wel as the phase shift per unit length. The longitudinal phas shifter, also named after its discoverers the "Reggia Spencer phase shifter," operates along the lines of a fer rite rotator. (Reference 16) Circularly polarized mode are set up inside the ferrite rod; the applied magnetic field usually below ferrite saturation, controls the phase con stant. Tapered transducers at both ends of the ferrit minimize the mismatch due to coupling from linear polar ization to circular polarization.

How well do these two ferrite phase shifters meet th desirable characteristics as outlined in the previous sec tions? Both are capable of providing 360 degrees o phase shift. Unfortunately, both are plagued by tempera ture, frequency, and power level effects. The longitudina unit, however, suffers more extensively, since it is usuall operated below saturation. Its performance is greatl affected by the value of saturation magnetization, becaus the effective magnetic field for phase shift is the differenc between the applied field and the opposing field due t the polarizability of the ferrite. The saturation magnetiza tion of all ferrites is temperature sensitive and is know to vanish at a temperature termed the "Curie Tempera ture." Such Curie Temperatures range from 80 to severa hundred degrees centigrade. As shown by measurement of a large variety of ferrites, (see Figure 17), a 10 pe cent degradation of saturation magnetization from that a 25°C appears between the temperatures of 35 to 80 de

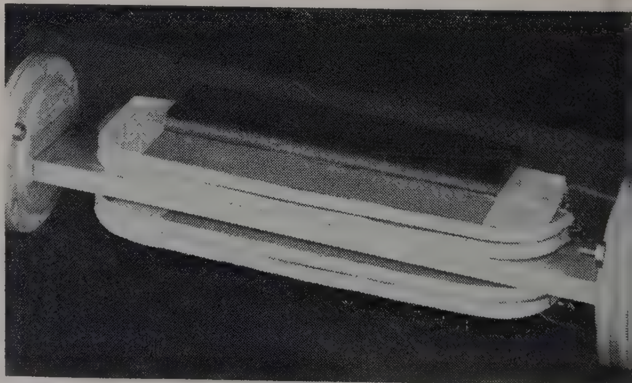


Figure 15 — Actual transverse field ferrite phase shifter.

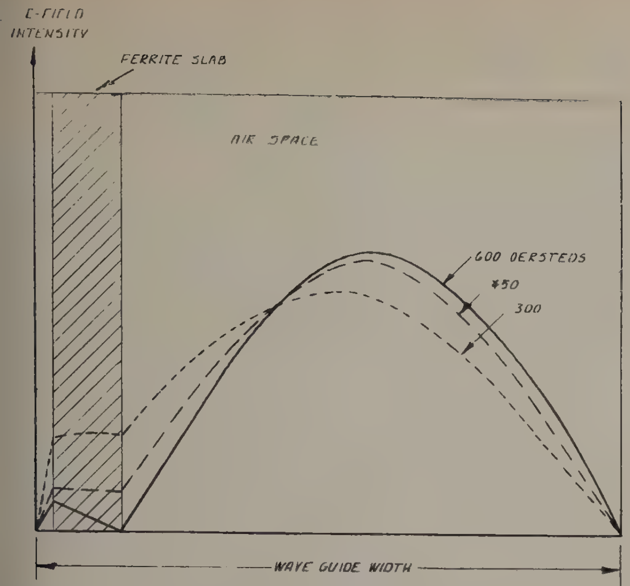


Figure 16 — E-Field pattern of transverse field ferrite phase shifter.

grees centigrade. This 10 per cent value becomes magnified since the applied magnetic field and the opposing demagnetizing field are of similar magnitude. For the transverse field phase shifter, this problem is greatly reduced since the operating magnetic field exceeds the demagnetizing field by sizable amounts.

Most ferrite phase shifters suffer from frequency dependency. This effect is somewhat more pronounced in the longitudinal field phase shifter since this device operates in a quasi-dielectric waveguide mode rather than the fundamental TE_{10} mode employed in the transverse field phase shifter, (Reference 16).

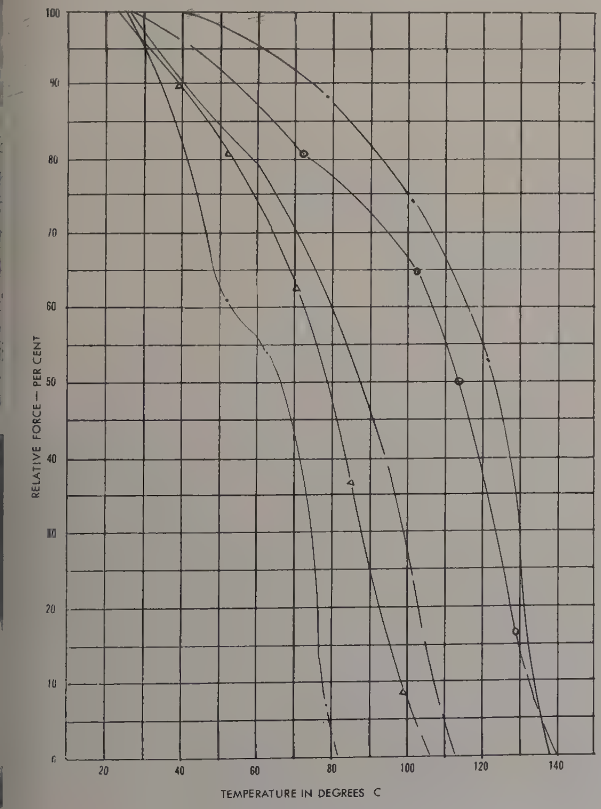


Figure 17 — Curie temperature test results.

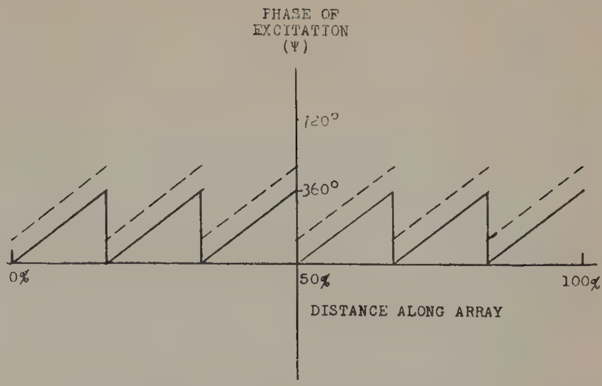


Figure 18 — Aperture phase function.

Phase shifter power handling capacity is limited mainly by the largest RF magnetic field excited inside the ferrite. The linearity of the permeability tensor breaks down and new RF absorption resonances appear when the RF field exceeds a maximum level established by the ferrite's saturation and magnetic band-width characteristics, (Reference 17). Since the transverse field phase shifter carries only small RF fields within the ferrite (see Figure 16), it can perform without deterioration up to 10 per cent of the rated power capacity of the waveguide in which it is placed.

A discussion of ferrite phase shifters would be incomplete without including their speed of response. The mechanical inertia of the non-electronic scanning antenna is now replaced by the electrical inertia of the magnetic circuit. The power required to change phase in a ferrite phase shifter (usually called "driving power") is taken as the time rate of change of stored magnetic energy. This evaluation is carried out most conveniently by taking half the product of coil inductance and the squared coil current and dividing the result by the time interval allowed for phase changing. Driving power should therefore be expressed as

$$\frac{\frac{1}{2}LI_2^2 - \frac{1}{2}LI_1^2}{\triangle t}$$

where I_1 and I_2 represent the coil currents before and after the phase change interval, $\triangle t$, and L, the inductance of the coil.

It is naturally desirable to design a phase shifter for as low a driving power as possible. This can be accomplished by operating with low magnetic fields, limiting leakage fluxes, and minimizing the reluctance of the magnetic circuit external to the ferrite piece. The longitudinal phase shifter requires about one-tenth the driving power of the transverse field phase shifter since its considerably lower magnetic excitation outweighs its extensive leakage flux fields.

It should be pointed out here that while the power capacity of each amplifier driving a ferrite phase shifter must be determined as described above, the sum total driving power for an entire antenna array is not necessarily the product of the power per phase shifter and the total number of phase shifters employed. This can be explained by referring to Figure 18. Here the phase variation across the aperture is illustrated for the case of a linear phase taper and a maximum 360 degree phase

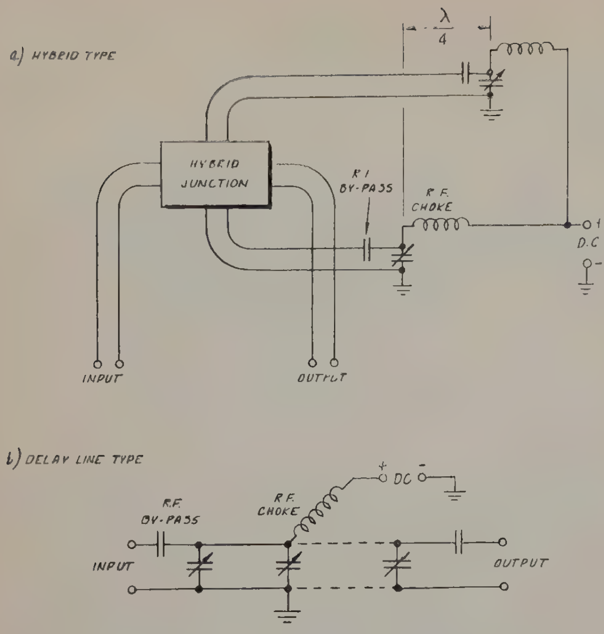


Figure 19 — Semiconductor phase changer.

excursion. (Dotted lines show the effect of equal phase error for all phase values) Since the phase function either expands or contracts along the horizontal axis during scanning, the phase change, which any one phase shifter must undergo, could be anywhere between +360 and —360 degrees with equal probability. Thus by providing storage devices in the driving amplifier circuits, those phase shifters changing to a lower magnetic excitation can be made to supply those whose magnetic energy is increasing. Then, except for I^2R losses, the driving energy of the system will be conserved.

Another type of ferrite phase shifter permitting continuously variable phase shift, which is furthermore independent of frequency and temperature, makes use of a rotating magnetic field (see Reference 18). Essentially a ferrite adaptation of the "Fox" phase shifter, this unit also consists of two quarter wavelength plates, to convert to circular polarization, between which a 180° differential section is placed. The ferrite structure has circumferential symmetry (an axial rod) but is linearly magnetized in a direction normal to that of the wave propagation. Magnetic excitation will produce a phase change only if the polarization of the propagated wave is parallel to that of the magnetic excitation. The orthogonal polarization remains unaffected. Thus a differential phase delay of 180 for two orthogonal polarizations can be produced. In place of the mechanical rotation of the Fox phase shifter, this phase shifter is rotated electrically by rotating the magnetic excitation field. This is accomplished by a series of windings driven by an alternating current and phased similarly to the armature of a synchronous motor. One such phase shifter is connected to each radiating element and driven by harmonically related alternating frequencies. A continuously increasing phase taper across the aperture can thus be produced and, depending upon element spacing, one or more beams can be made to scan continuously.

Several antenna laboratories have reported experimental ferrite scanned antennas. Among these are the Bell Laboratory (Reference 19) Hughes Aircraft (Reference 9) and W. L. Maxson (Reference 20). These systems which include ferrite driving and programming circuits have demonstrated the feasibility of ferrite scanning.

C. Semi-Conductor Phase Shifter

This unit employs a number of silicon crystals or P-N junction, variable capacitance, diodes ("Varactors," see Reference 21) arranged to form an RF delay line or to terminate two ports of a hybrid junction, (see Figure 19). The voltage applied to either type of diode varies its impedance. In the case of silicon crystals, the resistance is primarily affected, while in the case of varactors the capacity. In the hybrid circuit of Figure 19A, the diode impedance affects the phase of the reflection coefficient of the branching lines. If two diodes with identical characteristics are chosen and then excited by equal voltages, a phase shift equal to that of the reflection coefficient can be realized. This limits the maximum phase shift to ±90 degrees per crystal pair. However, actual crystal characteristics, as well as linearity and insertion loss requirements make only a ±45 degree phase shift practical. Similar limitations also apply to the delay line structure of Figure 19b. This design, furthermore, restricts diode capacity variations because of the associated characteristic impedance change and impedance mismatch. The need for eight or more elements in tandem raises the total phase shifter insertion loss to several db, thus somewhat higher than the 0.5 db values possible with ferrite phase shifters. In addition, crystals and varactors are not recommended for use at power levels in excess of several watts, as compared to tens of kilowatts for ferrite units. Due to poor reproducibility of diode impedances, a high degree of accuracy can only be achieved by means of individual unit calibration. Semi-conductor phase shifters, however, excel because of their exceptionally low driving power, which is computed as

$$\frac{\frac{1}{2}CE_2^2 - \frac{1}{2}CE_1^2}{\triangle t}$$

where C is the diode capacity; E_1 and E_2, diode voltages before and after phase change time interval, $\triangle t$. Typical diodes require only a few volts of excitation and possess less than 10 $\mu\mu f$ of capacitance. This makes it possible to accomplish microsecond slewing with about 50 microwatts of driving power.

D. Frequency Conversion Phasing Scheme

To circumvent the need for high speed, high accuracy RF phase shifters, a shift in frequency rather than phase can be employed. One such scheme, applicable mainly to receiving systems, places an RF mixer and preamplifier next to each antenna element. The amplified intermediate frequency signals are then recombined by means of equiphase lines. If the common local oscillator excites each mixer with the same phase, broadside antenna collimation is achieved. However, if a phase taper of L.O. signal is established along the line of mixers attached to the line of radiating elements, the effective beam will scan in accordance with the phase taper relationship $\triangle\psi = 360\ (d/\lambda)\ \sin\theta$, (see Figure 3). The key to the frequency conversion phasing scheme therefore, lies in method of phase shifting the local oscillator.

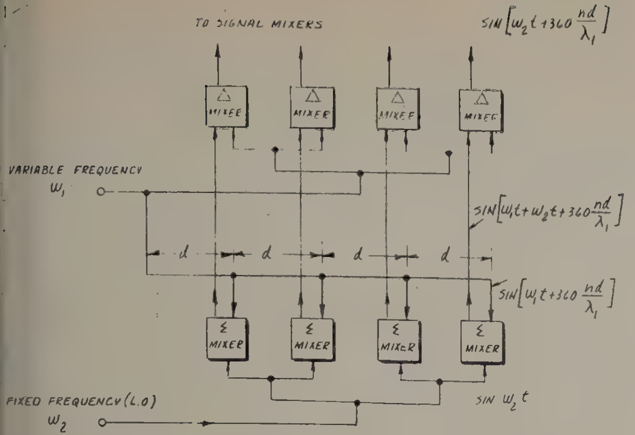


Figure 20 — Phase shifting by frequency shift and mixer technique.

A technique which converts a frequency shift into a phase shift has been developed for this purpose. As illustrated in Figure 20, an RF delay line of periodic delay distance, d, is used for feeding the variable frequency (ω_1) to a series of sum mixers. In addition, a fixed frequency (ω_2) is coupled to these same mixers through equal phase delays. This produces a sum output voltage from the n^{th} mixer proportional to sin $(\omega_1 t + \omega_2 t + 360 \frac{nd}{\lambda_1})$. Difference mixing of these sum output signals with equiphased variable frequency, ω_1, yields a voltage proportional to sin $(\omega_2 t + 360 \frac{nd}{\lambda_1})$. Thus ω_2 establishes the local oscillator frequency while ω_1 and d establish the differential phase $\Delta\psi = 360 \frac{d}{\lambda_1}$. By this method, the received beam direction can be selected by means of the variable frequency, ω_1.

The above phase shifting scheme can also be applied to a transmitting system, if the outputs from the difference mixers are fed to a bank of phase stable power amplifiers rather than to the signal mixers.

The frequency conversion phasing technique is equally as fast as frequency scanning. It also requires a frequency tunable oscillator and depends upon a frequency readout circuit for its beam positioning accuracy. Its chief drawbacks are the delicate phase balancing and phase stability requirement for the mixers, the dependence upon mixer crystals whose performance changes with age, and the high cost of transmitting amplifiers (one required for each radiating element). Radiation as well as reception of multiple beams and track-while-scan operation are possible here.

E. Ferrite Controlled Radiating Slots

It is possible to combine the radiating element and the phase shifter into a single component. This has been accomplished by use of waveguide radiating slots whose phase and amplitude are controlled electronically by means of ferrite discontinuities. (See Reference 22) A longitudinal, centered slot in the broad wall of a waveguide is employed and two dual ferrite irises are introduced on either side of it so as to create a variable magnetic field asymmetry in the waveguide mode. The magnitude of radiation of the slot increases with the amount of mode asymmetry while the phase of radiation depends upon the type of asymmetry. Even asymmetry is analogous to slot translation and shunt excitation, while odd asymmetry is analogous to slot rotation and series excitation. Since shunt and series excitation fields are 90 degrees out of phase with each other, any phase value can be generated by combined translation and rotation. Ferrite excited slots are best used in parallel-type corporate feeds, since in a series feed their transmission phase error would cause the phase of subsequent slots to be affected by the phase adjustment of any one slot. This technique, it appears, points the direction towards making antennas consisting of very large numbers of phase controlled elements.

F. Phase Scanning by Amplitude Modulation

In order to circumvent the need for a phase shifter a technique has been demonstrated utilizing amplitude variations for antenna beam scanning (see Reference 23). An array is needed consisting of quarter wavelength spaced and quadrature phased radiating slots. Specific amplitudes assigned to each radiating element give rise to an effective linear phase taper. Control of these amplitudes will then steer an antenna beam by altering the amount of phase taper. To arrive at the required amplitudes, the radiating pattern function must be resolved into an even and odd real function to obtain the even numbered slot amplitudes as well as an even and an odd imaginary function to obtain the odd numbered slot amplitudes. To further illustrate this scanning technique the excitation amplitudes for a uniformly illuminated linear array whose beam points at an angle θ (measured from the normal) are presented in Table I.

If one considers the radiating elements as pairs, the effective phase of each pair appears to advance due to the linear increase of the orthogonal vectors contributed by the odd number elements. This advance equals $2\pi \sin\theta$ radians per wave length along the array, which agrees with the phase requirement for scanning an angle θ, as illustrated in Figure 3.

VII BEAM SWITCHING ANTENNAS

The discussion of beam switching antennas should be divided into two basic categories: the technique for establishing multiple antenna beams and the technique for switching between them. Multiple beams call for the establishment of multiple phase tapers as controlled by a number of input feed points. This can be accomplished by exciting a single antenna reflector or a single antenna lens with a number of primary feeds physically displaced so that collimation takes place in different space directions. Earlier attempts along this line made use of a parabolic reflector or lens and a number of slightly defocused feeds. The resulting increase in side lobe level thus limited the number of beams to something like a 4 x 4 cluster with adjacent beams crossing over at —3 db. More recently a number of improvements have been made to lift the limitations of beam numbers as well as to compensate for the defocusing action. J. D. Barab reports a parabolic dome antenna which can produce a large number of pencil beams over a 360° sector (see Reference 24). Essentially a convex parabolic torus, whose diameter is somewhat larger than its focal distance, is constructed. The torus reflector is made of wires inclined at 45° to reflect only the polarization parallel to the wires and to become practically transparent to the orthogonal polarization. Inside this parabolic torus (which closely resembles

TABLE I: Amplitude of Excitation

Element No.	General	Small Scan Angle	Phase of Excitation
1	$\sin\left[\frac{5}{2}\pi\sin\theta\right]$	$\frac{5\pi}{2}\sin\theta$	−90°
2	$\cos\left[2\pi\sin\theta\right]$	1	0°
3	$\sin\left[\frac{3}{2}\pi\sin\theta\right]$	$\frac{3\pi}{2}\sin\theta$	−90°
4	$\cos\left[\pi\sin\theta\right]$	1	0°
5	$\sin\left[\frac{1}{2}\pi\sin\theta\right]$	$\frac{\pi}{2}\sin\theta$	−90°
6	1	1	0°
7	$\sin\left[\frac{1}{2}\pi\sin\theta\right]$	$\frac{\pi}{2}\sin\theta$	+90°
8	$\cos\left[\pi\sin\theta\right]$	1	0°
9	$\sin\left[\frac{3}{2}\pi\sin\theta\right]$	$\frac{3\pi}{2}\sin\theta$	+90°
10	$\cos\left[2\pi\sin\theta\right]$	1	0°
11	$\sin\left[\frac{5}{2}\pi\sin\theta\right]$	$\frac{5\pi}{2}\sin\theta$	+90°

a dome) a circle of feed horns is located. Each of these horns illuminates only a sector on the inside of this dome in the polarization parallel to the wire grating. A collimated beam is generated due to the parabolic elevation contour and circular azimuth contour of the reflector; this beam is directed along the diameter of the torus which includes the particular feed. Because of the 45° inclination of the reflecting wires, the collimated beam appears orthogonally polarized to the opposite side of the reflector and therefore passes through it. In contrast to the dome type of parabolic torus, which is a convex structure, a concave structure termed the "hourglass scanner" has been described by M. N. Fullilove in Reference 25. Again 360° of scan in a single plane is achieved, this time with a circle of feeds external to the reflector. Scanning with the above two systems is possible in one angular plane only. To achieve multiple beams in two angular planes, spherical reflectors are needed. Reference 26 illustrates this type of design. A parallel to the spherical reflector is the spherical "Luneberg" lens, which, because of its spherical symmetry, permits the placement of a number of feeds on the spherical locus for all focal points. The dielectric constant for the lens is selected so that rays emanating from any focal point will experience equal phase shifts after passing through the lens.

Another well-known beam switching antenna is the circular "Wullenweber" array. This consists of a circle of outwardly radiating antennas coupled to an RF switch. The lines connecting to the individual antennas usually form the stator of the RF switch and are equal in length. The switch rotor usually consists of a corporate feed or power dividing network, which controls the illumination taper, and phase compensating sections which provide the maximum delay for the center elements and less for the extreme elements, in accordance with the geometry displayed in Figure 2. In most cases approximately 1/6 of the elements are excited at any one time. While some systems will only provide step scanning between fixed beam positions, others attempt to produce a uniformly rotating beam. Examples of the latter are given in References 27 and 28, where a multihorn waveguide feed rotates and couples to a stationary waveguide system, both when rotor and stator feeds are in line as well as when they are

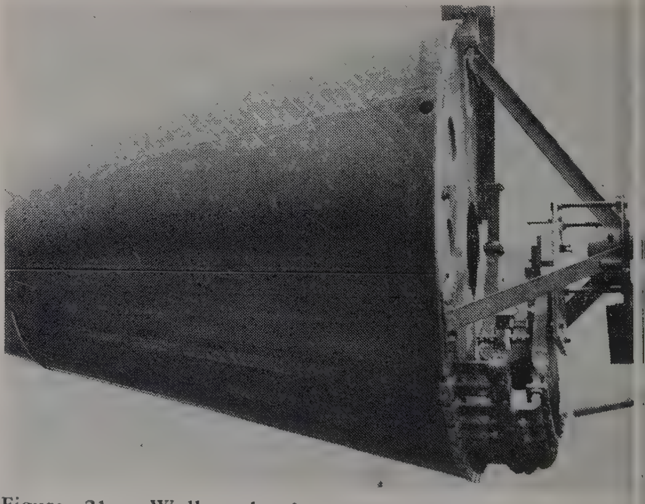


Figure 21 — Wullenweber-frequency scanned two-dimensional array.

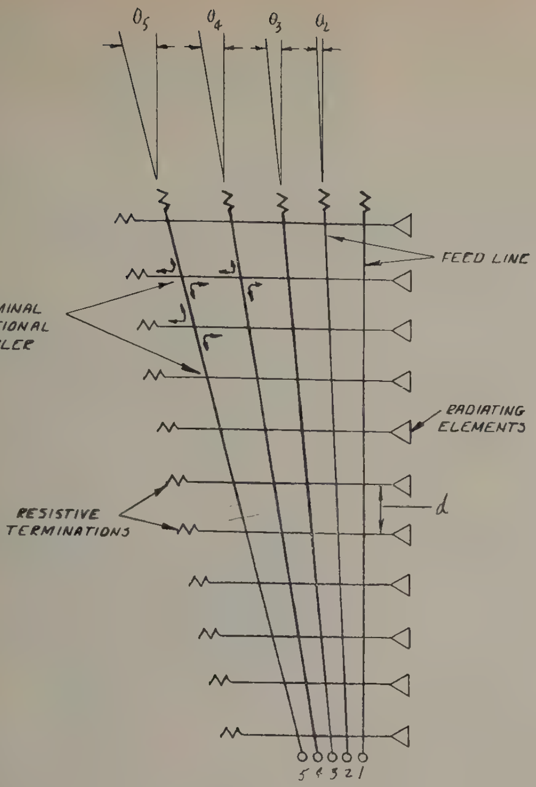


Figure 22 — Multi-beam antenna with directional couplers.

staggered. The antenna described in Reference 28 and illustrated in Figure 21 combines a Wullenweber type, uniformly scanning beam in one plane with a frequency-scanned beam in the orthogonal plane. This necessitated multiple wavelengths long phase-compensating lines in order to accommodate the different phase corrections needed for each scan angle when the beam is scanned orthogonally by frequency. Because of this added difficulty only —17 db side lobes were obtainable while better than—20 db side lobe arrays have otherwise been built.

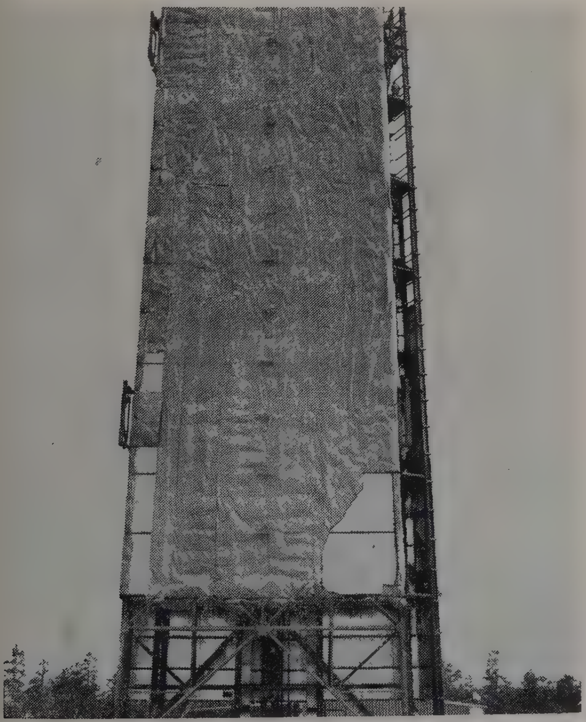


Figure 23 — Practical 80-beam antenna array (150 feet high).

A different approach, not plagued by the above beam number limitation, makes use of a network of directional couplers, (see Figure 22 and Reference 29). All lines in this diagram represent straight sections of transmission line, while the intersections represent directional couplers, whose coupling directions are shown by arrows. The phase taper established by any one feed the line, i.e., line connecting one input port to all the antenna elements, is expressed as:

$$\frac{\Delta\psi}{d} = \frac{360}{\lambda} \text{ (sec } \theta - \tan \theta\text{) degrees per unit length}$$

(All symbols explained in Figure 22)

Since the element separation, d, is usually in the vicinity of a half wavelength, the term (sec θ — tan θ) would have to be either 0 or 2 and $\theta = 90$ or -90 degrees to produce broadside radiation. Consequently, a 180-degree phase reversal is incorporated either at every other directional coupler or at the radiating element. By employing directional rather than bilateral couplers, coupling between the various input points is practically eliminated. Figure 23 illustrates a 150-foot high, 111-beam antenna array of this type.

Many solutions are presently available for the technique of switching between beams; the particular choice depends mainly upon the specific system requirements. High switching speeds call for ferrite, gas tube, or semiconductor switching (Figures 24a, b, and d); low insertion loss for mechanical switching (Figure 24c); high RF power for ferrite or mechanical switching; high reliability with fixed switching sequence for rotary commutator type switch (see Figure 24e). In many instances, however, practical considerations, such as size, weight, and cost, might be the deciding factors, rather than performance. The switching problem is usually considered secondary next to the multiple antenna beam technique.

The beam positioning accuracy of a multibeam system is usually very high, since the aperture phase taper is established through the design rather than altered during the scanning interval; for the same reason low side lobes are also obtained. An added feature of multibeam antennas is that the various phase tapers, i.e., beam directions, may be utilized simultaneously by employing one transmitter and/or receiver at each input feed point.

VIII Conclusion

The intention of this paper has been to acquaint the reader with several varieties of electronic scanning antennas available today. There are undoubtedly many other possible schemes; some, yet to be exploited; some modifications and combinations of those presented here, and others which cannot be divulged here because of security regulations.

The foregoing illustrations of electronically scanned antennas should have demonstrated that the elimination of the mechanical drive system has been achieved at the expense of additional electrical complexity. The antenna feed structures have become somewhat more cumbersome, less reliable, and certainly more expensive. A good deal of the future engineering in this field will have to be devoted toward overcoming these drawbacks.

It appears that this field deserves considerably more experimentation to produce antenna systems possessing the accuracy and reliability of the mechanically scanned antennas they hope to replace. Keeping in mind the rewards of high speed antenna scanning performance, of

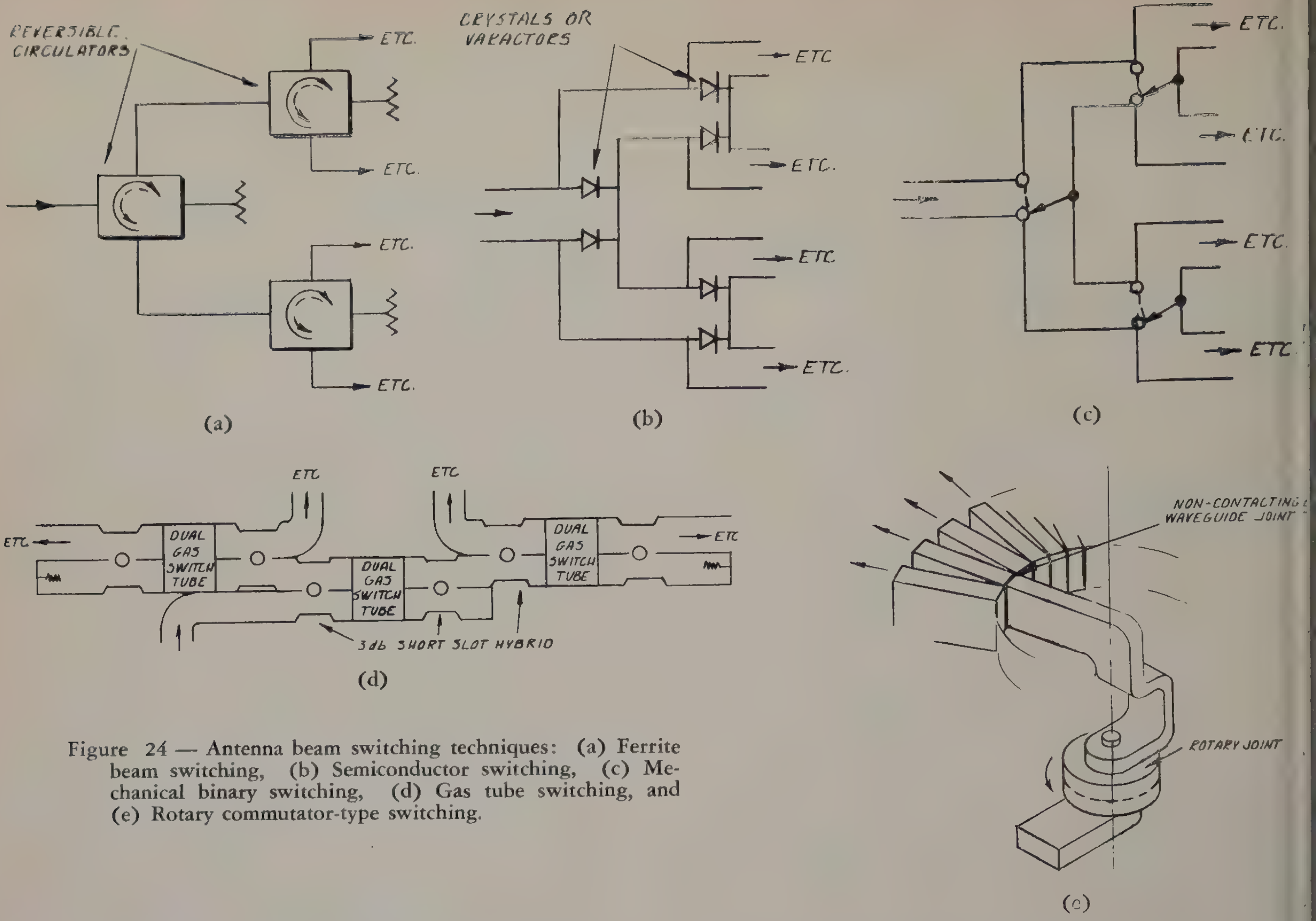


Figure 24 — Antenna beam switching techniques: (a) Ferrite beam switching, (b) Semiconductor switching, (c) Mechanical binary switching, (d) Gas tube switching, and (e) Rotary commutator-type switching.

combining the functions of a large number of antennas (and, for that matter, radars) in a single system, and of achieving entirely new antenna performance and antenna applications, sustained efforts in the field of electronic scanning can be predicted in this challenging antenna specialty.

ACKNOWLEDGMENT

I hereby wish to express my appreciation to the U.S. Army Signal Corps, the Air Force Development Centers, and the Federal Aviation Agency, who have sponsored antenna development programs at The W. L. Maxson Corporation, New York, N. Y.

Figures 5, 9, & 15—have been reproduced by the courtesy of the U.S. Army Signal Corps.

Figure 4, & 21—by the courtesy of the Wright Air Development Center.

Figure 23—by the courtesy of the Federal Aviation Agency.

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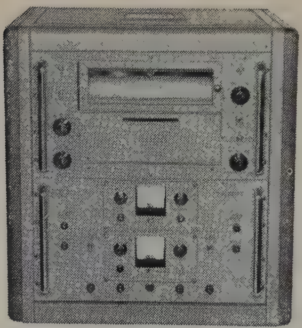

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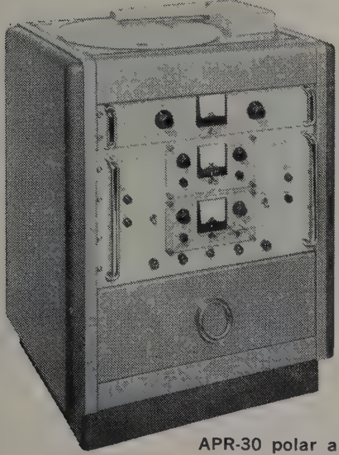

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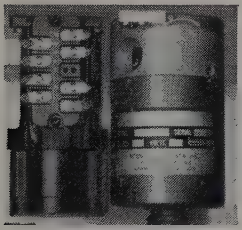

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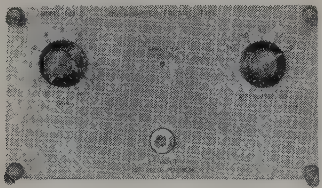

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Industry News

(Continued from page 36)

SANDERS ASSOCIATES ACQUIRES NEW PLANT

Sanders Associates, Inc., Nashua, N. H., has acquired a new facility on Route 128 in the new industrial park in Burlington, Mass., as a production and engineering plant. Added capacity of the modern plant will help reach the company's recently announced forecast of a sales increase of 50 per cent to more than $25 million this fiscal year and $40 million next year.

In this latest addition to Route 128's "electronic belt", employment is foreseen as growing to a total of 300 to 500 people, including engineering and production personnel, according to company officials. While some top engineering posts will be filled from present personnel, recruiting for the enlarged engineering staff will start immediately.

Operations at the new Burlington plant will require more than a quarter of a million dollars worth of production and engineering equipment in order to start scheduled operations in 60 days. Operations will include development and production of advanced electronic weapon systems for aircraft, missile guidance, and missile defense.

Expansion plans for the facility, at present occupying 30,000 square feet, will include new construction of a 50,000 square foot plant to start in the spring "Ultimately," said Mr. Sanders, "the plant will be expanded to 100,000 square feet."

This is the second new facility to be acquired recently by Sanders Associates as part of a more than $2 million expansion program. Earlier, purchase was arranged for a new plant in Plainview, L. I. This plant is also scheduled for enlargement to 100,000 square feet.

—*mwj*—

NARDA PROMOTES THREE ENGINEERS

Three promotions in the engineering staff of the Narda Microwave Corporation, Mineola, L. I., have been announced by Stuart D. Casper, vice president in charge of engineering.

Howard S. Bertan, currently manager of the company's High Power Electronics Division, will assume additional responsibilities as group leader for the Electronic Products Division. This division is responsible for the design and development of VSWR amplifiers, power meters and power supplies.

Adolph Brenner has been appointed senior microwave engineer in charge of the development, as well as the improvement of Narda's attenuators, frequency meters, terminations, detectors, and other products.

Donald Elkort has been named group leader for ferrite devices and will be in charge of designing and developing ferrite devices such as circulators, isolators, modulators, and phase shifters.

—*mwj*—

(Continued on page 68)

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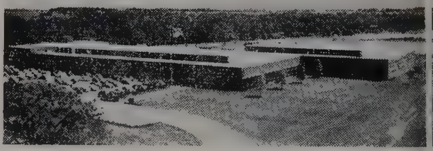

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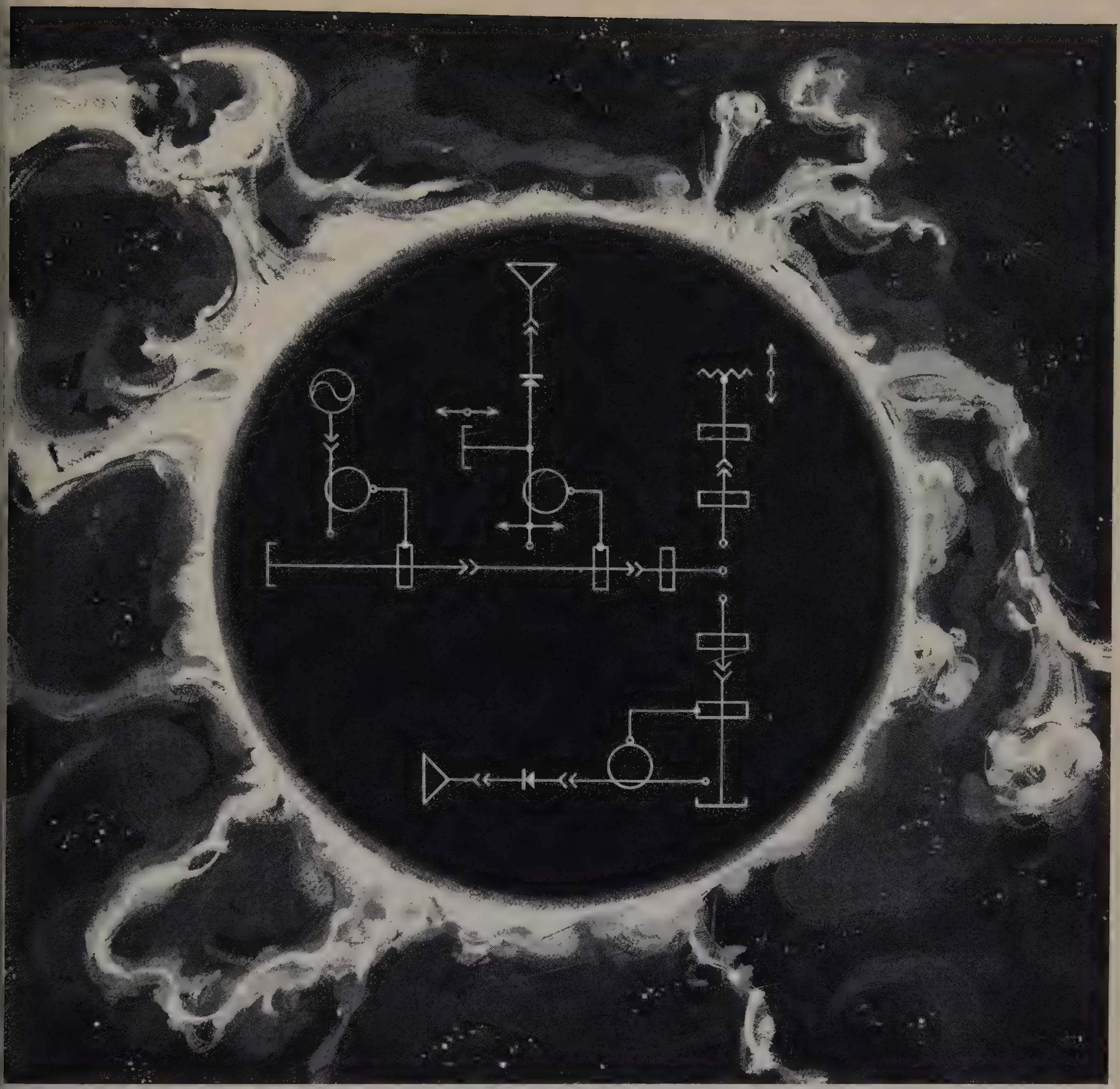

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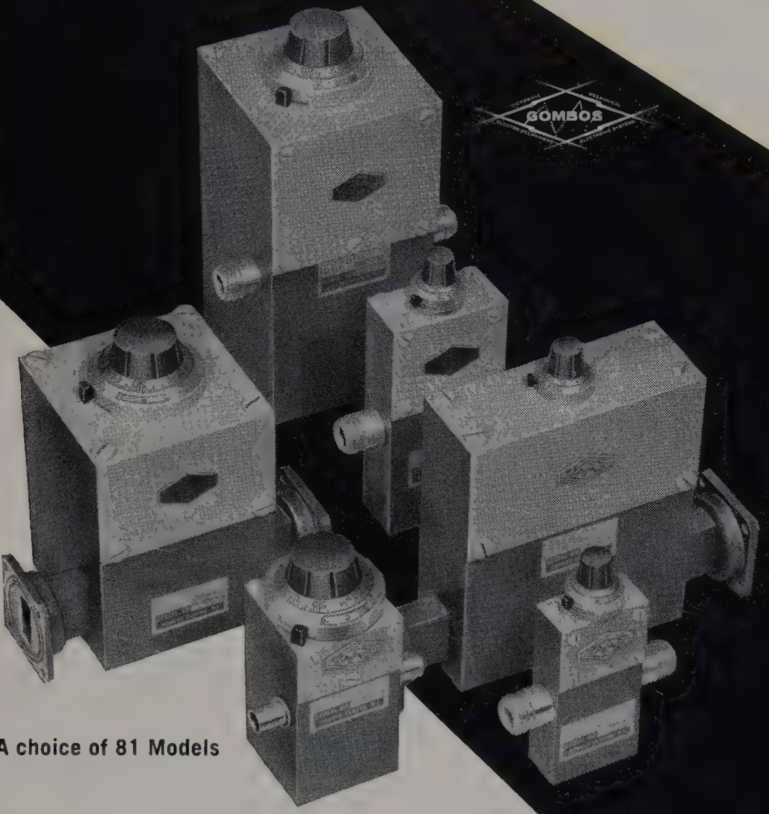
Above: The schematic shown expressed in standard symbols, is a typical I-T-E bench test set-up for coupling measurements for a WR2100 waveguide switch. Other large waveguide components range from WR770—WR2300.

Write for I-T-E's new catalog of Large Waveguide Components.

I-T-E CIRCUIT BREAKER COMPANY
Special Products Division • 601 E. Erie Avenue • Philadelphia 34, Pa.

Circle Reader Service Card 30

TUNABLE BAND PASS
FILTERS



A choice of 81 Models

A COMPLETE LINE FROM 500MC TO 18,000MC

Single knob tuning
2, 3, & 4 Section models offer a selection of rejection characteristics
Low insertion loss (1.0 D.B. Max.)
Coaxial or waveguide application

The John Gombos Co., Inc. line of TUNABLE MICROWAVE BANDPASS FILTERS is designed for laboratory application such as Image Filters, Noise Measurements, Harmonic Rejection, Frequency Selection and Spectrum Analysis. These filters are also designed for systems applications such as Video or Superheterodyne Preselection, Resonant Diplexing, Frequency Discrimination, Multiplexing and Band Elimination.

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WEBRO ROAD, CLIFTON, N. J.

WRITE TODAY for literature on the John Gombos Co., Inc. line of Triode Oscillators and Amplifiers, Tunable Band Pass Filters and Front End Assemblies. We would also appreciate receiving your special requirements for active and passive Cavities, Components and Sub-systems.

(Continued from page 66)

G. E. FORMS TRAVELING-WAVE TUBE PRODUCT SECTION

General Electric Company has completed a major reorganization of its Microwave Laboratory in Palo Alto, Cal., to orient it toward one of the fastest growing segments of the electronics market — traveling-wave tubes.

The laboratory, formerly an engineering section of the company's Power Tube Department, headquartered in Schenectady, N. Y., has been made a separate product section of the department and renamed the Traveling-Wave Tube Product Section.

In announcing the formation of the new component, Power Tube Department General Manager J. F. McAllister also named Dr. Chester G. Lob as manager.

Dr. Lob formerly was manager of Low Power Traveling-Wave Tubes at the Microwave Laboratory. He succeeds Dr. Alden H. Ryan who has been named Operations Analyst.

According to Mr. McAllister, the new organization will operate as a completely integrated business and will result in improved customer service from the standpoint of faster quotations, better delivery and increased application engineering assistance.

Products to be made will include a broad range of high and low power traveling-wave tubes, harmonic filters, duplexers and certain specialized klystrons.

The Palo Alto plant now has about 80,000 square feet of administrative, laboratory and manufacturing space, and employs approximately 350 persons.

According to Mr. McAllister, the new product section will continue to pursue much of the advanced microwave research and developmental work which was in the Microwave Laboratory.

— m w j —

AEL CELEBRATES TENTH WITH EXPANSION

American Electronic Laboratories, Inc., Philadelphia, Pa., noted its tenth anniversary by starting construction on a new 32,000 square foot plant at Colmar, Pa. Dr. Leon Riebman, president, and Conrad J. Fowler, senior vice president, two of the original founders, and several local officials participated in the ground-breaking ceremonies.

Early in 1961, A.E.L. expects to be in full operation at the Colmar site, with production of its line of industrial and microwave communications and electro-medical products. The 55 acre site provides long test paths for research in the fields of microwave communications, antenna research and development, and satellite tracking devices.

The new modern air-conditioned building is designed for expansion, and A.E.L. expects that it will double in size within the next two years. The company expects to expand its personnel to some 350 people by 1962.

— m w j —

TUBES POWER EARLY WARNING RADAR

High power microwave tubes produced by Varian Associates, Palo Alto, Cal., are a vital part of America's newest early warning radar system at Thule, Greenland, near the Arctic Circle.

The klystrons pulse out super-sensitive microwave beams to detect possible ballistic missiles headed toward America. Part of the Air Defense Command's radar shield in the Far North, the tubes provide enough power so the radar system can detect missiles 3,000 miles away.

The tubes are a vital part of the BMEWS (Ballistic Missile Early Warning Surveillance) station recently put into operation at Thule. Other BMEWS stations are under construction at Clear, Alaska, and Fylingdales Moors, Yorkshire, England. The complete BMEWS system is expected to provide at least 15 minutes warning of any enemy ballistic missile attack.

Prime contractor for the project is Radio Corporation of America. General Electric Co., Syracuse, N. Y.; and Continental Electronics Mfg. Co., Dallas, Texas are major subcontractors. Varian supplied the klystron tubes.

— m w j —

GOODMAN APPOINTED DISTRICT REPRESENTATIVE

Roy G. Goodman has been appointed District Representative for Motorola's microwave department with offices in Phoenix, Ariz. He is responsible for the sale of all Motorola microwave and industrial control products in Arizona, Utah, Nevada, and Colorado.

Goodman comes to Motorola from the Arizona Highway Department, where he was chief communications engineer. He holds a degree in electrical engineering from the University of Arizona and acquired radio and radar experience while in the Air Force during World War II.

— m w j —

RAYTHEON TO SUPPLY NAVY WITH HARBOR SURVEILLANCE RADAR AND COMMUNICATIONS SYSTEMS

Twelve air-transportable harbor surveillance radar and communications systems will be supplied to the Navy by Raytheon Company's Commercial Apparatus and Systems Division, Norwood, Mass., under terms of a contract announced recently.

The contract, which exceeds $1,500,000 for equipment and spare parts, includes Raytheon's Mariners Pathfinder Model 1600 radars and various units of microwave communications and radar relay equipment. All major units of the new radar surveillance centers are standard commercial devices.

The Model 1600 Radar, basic unit in the systems, employs a slotted waveguide antenna 12 feet long to provide an extremely narrow horizontal beam contributing to a high-definition picture. This type of antenna reduces side lobes and eliminates back radiation common with reflector systems. The simpler mechanics also improve watertight integrity and serviceability.

Harbor contours and ships entering and leaving port are displayed on a 16 inch cathode ray tube. A short pulse width of only 0.05 microseconds, less than half that found in most commercial radars, is used on the radar's shorter range scales to provide high-definition. The radar's seven range scales are ½, 1, 2, 4, 8, 20, and 50 nautical miles.

The relay equipment includes Raytheon microwave links such as those used to send color television signals and to transmit data and control signals for other communications purposes.

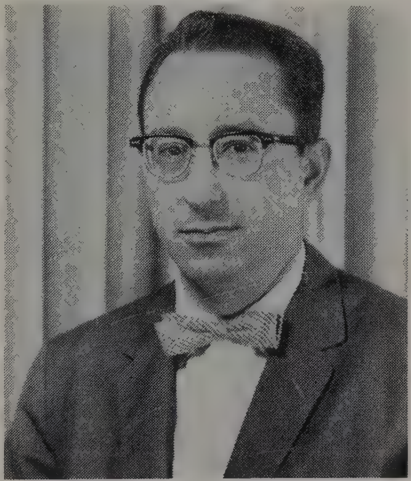
The twelve harbor surveillance systems are scheduled for delivery to the Bureau of Ships over the next 13 months.

— m w j —

MICROWAVE DEPARTMENT MANAGER NAMED AT PHILCO-LANSDALE DIVISION

The appointment of E. Gonzalez-Correa to the newly created position of manager, microwave department, was announced today by Dr. C. H. Sutcliffe, general manager of the Special Products Operations of Philco Corporation's Lansdale Division, Lansdale, Pa.

In his new position Mr. Gonzalez assumes over-all responsibility for activities in microwave device and circuit development, engineering, production, testing, and materials development.



Mr. Gonzalez joins the Lansdale Division following four years of service in the Philco Research Division, first as manager of solid state research planning and more recently as executive coordinator of technical programs of the Research Division Staff.

He has been active in the field of solid state devices since 1952. As chief of the Circuit Research Units, Frequency Control Branch, U. S. Army Signal Corps, he directed a group which initiated a study program at the Ft. Monmouth, N. J. Engineering Laboratories, aimed at the application of semiconductor devices in frequency control and switching circuitry. Subsequently he was placed in charge of the section of the Signal Corps Engineering Laboratories responsible for the device and application engineering aspects of that facility's transistor and diode program.

— m w j —

(Continued on page 71)

MICROWAVE MECHANICAL GOMBOS ELECTRO-MECHANICAL ELECTRONIC SYSTEMS

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MICROWAVE
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WRITE TODAY for literature on the John Gombos Co., Inc. line of Triode Oscillators and Amplifiers, Tunable Band Pass Filters and Front End Assemblies. We would also appreciate receiving your special requirements for active and passive Cavities, Components and Sub-systems.

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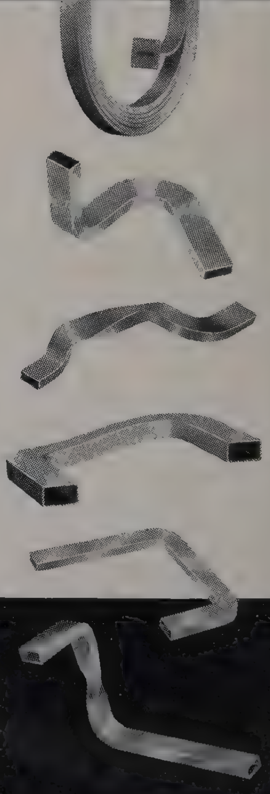

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TO YOUR SPECIFICATIONS

Whatever your needs — bends, twists, offsets, coils, transitions, fabrications, complete assemblies — Specialty Automatic is ready to precision manufacture to your prints.

In 1947 Specialty Automatic was first called upon to help solve intricate and complex waveguide bending problems. Since then it has rapidly become one of America's leading suppliers of waveguide bends. With its advanced techniques and rigid quality control, Specialty Automatic will continue to assure satisfaction in your every waveguide bending requirement.

Send for brochure — "the technique of precision waveguide bending".

Specialty AUTOMATIC MACHINE CORPORATION

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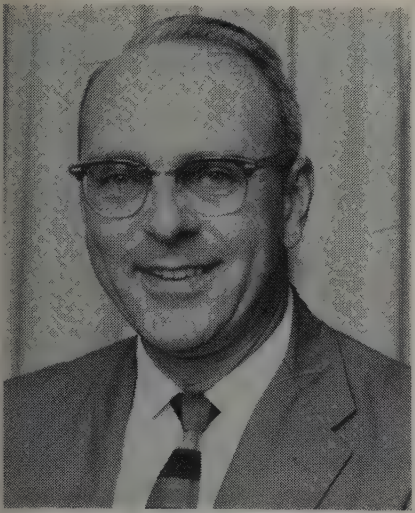
Industry News

(*Continued from page 69*)

McCLENAHAN NAMED MARKETING MANAGER AT SPERRY



William J. McClenahan has been named marketing manager of Sperry Rand Corporation's Sperry Electronic Tube Division, Gainesville, Fla.

McClenahan's new responsibilities include contracts, sales planning, advertising, and promotion of the Division's line of klystron and traveling-wave tubes. These responsibilities cover both U. S. and foreign markets.

Before transferring to the Sperry sales organization in 1956, McClenahan was field engineering supervisor in Sperry's Southwest District. In that capacity, he had broad experience with both military and commercial electronic systems. He was named sales manager of the Gainesville operation in 1958.

—*mwj*—

ANDERSON, PRESIDENT OF FXR, INC., HONORED BY NEW JERSEY ENGINEERS

An award for exceptional services has been presented to Tore N. Anderson, president of FXR, Inc., Woodside, N. Y., manufacturer of microwave test instruments and associated high frequency equipment, by the Northern New Jersey section of the Institute of Radio Engineers.

The citation accompanying the award paid tribute to Mr. Anderson's "untiring efforts" in recognizing the need for a means of communications among members and establishing the group's Northern New Jersey Newsletter.

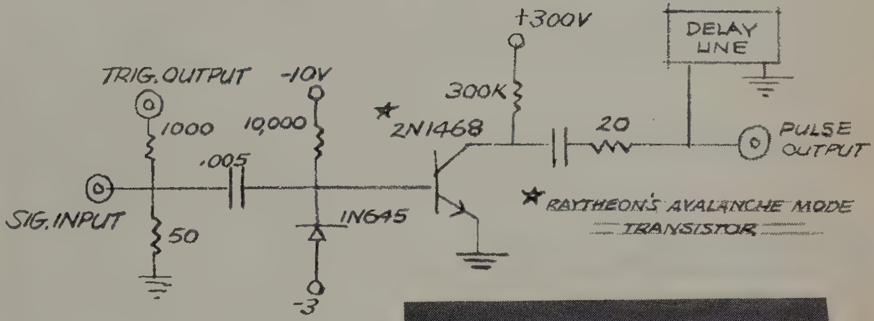
"By his detailed administration," the citation said, "this Newsletter has become a worthy means of reporting section activities and also a self-supporting publication in view of excellent business administration and advertising sponsorship."

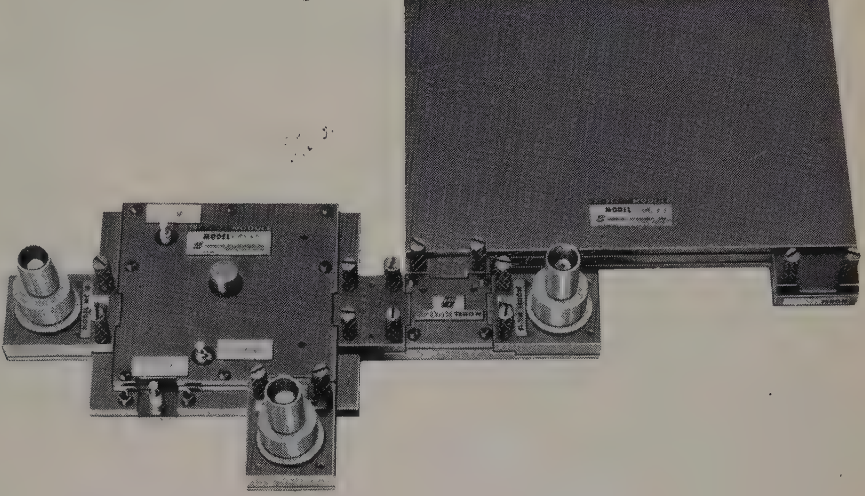
Mr. Anderson, active in professional engineering groups, is a Defense Department consultant and has been designated head of the secretariat of an international committee establishing worldwide standards for waveguides and waveguide connectors.

—*mwj*—

(*Continued on page 72*)

SWITCHING SPEEDS AS FAST AS 0.7 NANOSECONDS ARE NOW FEASIBLE





This pulse amplifier's fractional nanosecond rise time is made possible by Sander's TRI-PLATE® Strip Transmission Line Modules!

RAYTHEON'S ADVANCED PULSE AMPLIFIER consists entirely of Sanders TRI-PLATE breadboarding modules . . . both custom-engineered and off-the-shelf. The 2N 1468 Avalanche Mode Transistor used was merely plugged into the circuit completing the fastest available transistorized pulse amplifier. These and other TRI-PLATE strip transmission modules are today's means of keeping pace with tomorrow's high-speed switching developments.

MOST SANDERS TRI-PLATE MODULES are available from stock in standard impedances of 50 and 10 ohms for breadboarding or production use. Custom-engineered modules are quickly supplied in a range from 5 to 100 ohms. Sanders TRI-PLATE catalog currently lists more than 125 different modules including: mounts for transistors, tunnel diodes, varactors, and switching diodes; coax transitions; attenuator pads; delay and slotted lines; tees and other TRI-PLATE components for high-speed switching and microwave applications. For your TRI-PLATE catalog use the Reader Service card or write directly:

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SANDERS ASSOCIATES, INC.

Product Manager, Microwave Products Dept., NASHUA, NEW HAMPSHIRE

New TRAK Type 2959,
1.5 KMc, tuneable
±50 Mc

7 NEW Miniature MICROWAVE OSCILLATOR CAVITIES now available

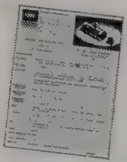
TRAK Electronics Company, Wilton, Connecticut, announces the formation of TRAK MICROWAVE CORPORATION to increase its developmental facilities for triode cavities in r-f signal generation from 500 Mc upwards. Present low, medium and high power cavities are available for application in grid pulse, plate pulse, and CW service.

TRAK expanded its Microwave Cavity line, which started in 1949, by adding the following 7 NEW miniature Cavities in 1960:

TRAK Type 9127-L	At 1090 Mc, tuneable ±25 Mc, available from 900—1200 Mc.
TRAK Type 2958	At 925 Mc, tuneable ±50 Mc, available from 500—2200 Mc.
TRAK Type 2959	At 1.5 KMc, tuneable ±50 Mc, available from 500—2200 Mc.
TRAK Type 9127-SL	At 2 KMc, tuneable ±100 Mc, available from 800—7000 Mc.
TRAK Type 9127-S	Available in 3 segments of S-Band: 2700—3000 Mc, 3000—3300 Mc, 3300—3600 Mc.
TRAK Type C-3136	Tuneable 2700—3400 Mc.
TRAK Type 9127-C	Tuneable 5400—5900 Mc.

ALSO, OSCILLATORS ENGINEERED to your specifications!

We invite you to write for new TRAK MICROWAVE CAVITY BULLETIN.



Cavity Oscillator ENGINEERS WANTED. Resumes invited.

TRAK MICROWAVE CORPORATION
Subsidiary of
TRAK Electronics Company
5006 N. Coolidge Avenue
Tampa 3, Florida
REdwood 6-6422

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(Continued from page 71)

MARTIN RICHMOND HEADS NEW LABORATORY

Martin R. Richmond, Corporate Vice President of Sanders Associates, Inc., Nashua, New Hampshire, has been named to head the company's new Advanced Systems Laboratories on Route 128 in Burlington, Mass.

Mr. Richmond is one of the founding group of Sanders Associates and has directed their highly successful research and development activities over the past 9 years. At Raytheon from 1946 to '51, he was credited with developing the basic operating methods for missile guidance which have been used in Sparrow III, Hawk, Advanced Terrier, and Tartar missiles.

According to President Royden C. Sanders, Jr., the new laboratory will be headed by key personnel from the company's Nashua headquarters, plus an additional number of skilled engineers and technicians now being sought. Among the immediate tasks of this new facility are the further developments of the target seeker system in the Navy's new Eagle long-range air-to-air missile as well as space communications, advanced weapons systems, other space technologies and anti-ICBM work.

With 20 years of experience, Mr. Richmond is considered a leader in the design of radar and missile guidance equipment. He is co-inventor of the pulse doppler PANAR® (panoramic surveillance radar) which was a significant advance in radar techniques. Now a member of the Defense Department's Advisory Group on Radar and the Mutual Weapons Defense Program, he was awarded the Meritorious Service Citation by the Secretary of the Navy in 1958.

After graduating from Brooklyn Polytechnical Institute, Mr. Richmond joined the RCA Laboratories to participate in the development of UHF radar systems and altimeters. With the Navy during World War II he was assigned to the Navy's blind bombing operational equipment.

—*mwj*—

CWS NAMES ITALIAN, CANADIAN REPS

CWS Waveguide Corp., Lindenhurst, Long Island, manufacturer of microwave components for the radar and communications industries, has appointed Metroelettronica Co. of Milano as sales representative for all of Italy. In another expansion of its Foreign Sales Division, CWS Waveguide has named The Glendon Co., Ltd., Toronto, Ont., as sales representatives for the Dominion of Canada.

—*mwj*—

MICROWAVE CORPORATION OF AMERICA APPOINTS HOWARD AS PRODUCTION MANAGER

Microwave Corporation of America, Stamford, Conn., has announced the appointment of John D. Howard as production manager. Mr. Howard was formerly production manager for Bogart Manufacturing Company, Brooklyn, N. Y., one of the larger microwave components and instrument manufacturers. He has more than twelve years of experience in management of manufacturing in waveguide and related components and sub-systems.

—*mwj*—

ESC ELECTRONICS APPOINTS QUALITY CONTROL MANAGER

ESC Electronics Corp., Palisades Park, N. J., manufacturers of Delay Lines, Filters, Pulse Transformers and other types of video networks, announces the appointment of John P. Jacobic as quality control manager.

In his new capacity, Jacobic will be responsible for all quality control procedures attendant to the manufacturing of the complete ESC product line.

A former U. S. Air Force Inspector, Jacobic was previously associated with the Kearfott Co., Little Falls, N. J.; the Martin Co., Orlando, Fla., and Autonetics, a Division of North American Aviation Inc., Downey, Cal.

—*mwj*—

(Continued on page 75)

POLARAD

NEW! CALIBRATED FIELD INTENSITY RECEIVER

1,000 to 10,000 mc*

Model FIM

ONE UNIT

combines receiver, internal signal generator and power supply

ONE DIAL SET

tells you frequency and absolute power level

ONE INSTRUMENT

gives you calibrated answers to your RFI problems

- Single self-contained instrument combines calibrated receiver and signal generator with complete power supply.
- The only Field Intensity Meter approved Category A MIL-I-26600 at these frequencies.
- Model FIM accurately measures frequency and absolute power level of conducted or radiated microwave energy.
- The only microwave Field Intensity Meter with self-contained signal generator which calibrates entire system under test at any level.
- First single microwave test system to determine r-f interference and susceptibility.
- Front-panel meter indicates average, peak, slide-back peak or quasi-peak value of r-f signals. Outputs for video, audio and recorder.
- Four interchangeable tuning heads cover 1,000 to 10,000 mc.*
- Direct-indicating peak VTVM for ease of frequency location of impulse noise.
- Single UNI-DIAL tuning control tunes both the receiver and signal generator.
- Calibrated antenna system includes an omni-directional broad band antenna and a separate directional antenna to match each tuning unit.

*Two compatible tuning units under development will extend frequency to 20,000 mc.

MAIL THIS CARD for specifications. Ask your nearest Polarad representative (in the Yellow Pages) for a copy of "Notes On Microwave Measurements."

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Please send me information and specifications on:

☐ Model FIM Calibrated Microwave Field Intensity Receiver
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☐ Model MSG-1 and MSG-2A Signal Generators
My application is__________

(See reverse side)

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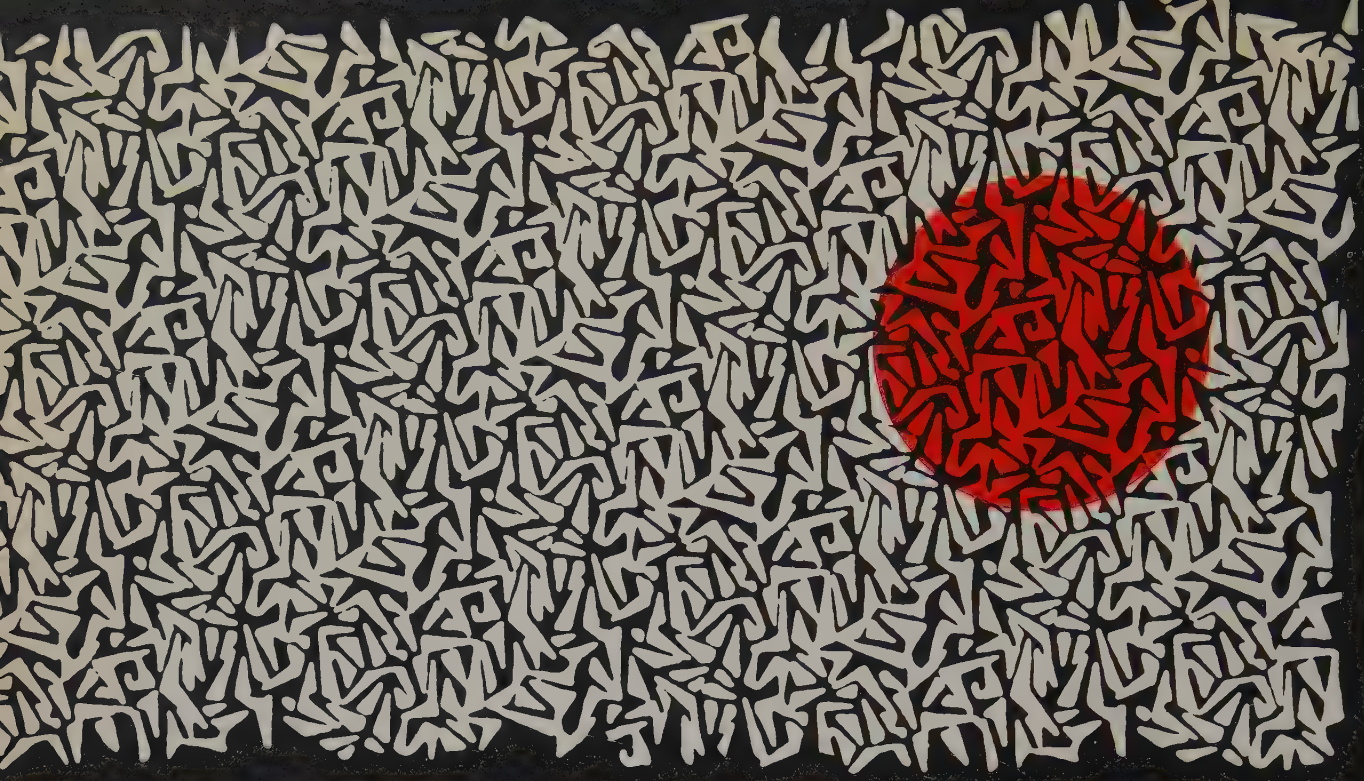

Model MSG-2A

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POLARAD

MICROWAVE SIGNAL GENERATORS

950 to 4,600 mc

PROVEN DESIGNS Generate Signals of Calibrated Frequency and Power Output Level.

- Provide internal pulse, square wave, FM and CW outputs.
- Versatile single or multi-pulse external modulation.
- Continuously adjustable pulse repetition frequency, pulse width and pulse delay.
- Frequency accuracy: ±1 percent.
- Power output: 1 milliwatt (0 dbm)

MODEL	FREQUENCY
MSG-1	950 to 2,400 mc
MSG-2A	2,000 to 4,600 mc

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43-20 34th St., Long Island City 1, N. Y.

(Continued from page 72)

1961 IRE INTERNATIONAL CONVENTION SET

March 20 through 23 have been selected as the dates for the 1961 IRE International Convention, which will again be held at the Waldorf-Astoria Hotel and New York Coliseum in New York City. More than 70,000 engineers and scientists from 40 countries are expected to attend what has become the world's largest technical meeting and exhibition.

A comprehensive program of 275 papers, covering the most recent developments in the fields of all 28 IRE Professional Groups, will be presented in 54 sessions at the Waldorf-Astoria and the Coliseum. The high point of the program will be a special symposium on new energy sources to be held Tuesday evening, March 21, at the Waldorf. The complete program will be announced in January.

The IRE Show, filling all four floors of the Coliseum, will accommodate approximately 850 exhibitors. Some $15,000,000 worth of the latest electronic equipment will be on display, most of it for the first time.

The social events will include a "get-together" cocktail party Monday evening and the annual IRE banquet Wednesday evening, both in the Grand Ballroom of the Waldorf. The banquet will feature the presentation of IRE Awards for 1961, including the Medal of Honor to Ernst A. Guillemin, Professor of Electrical Engineering at MIT, and the Founders Award to Ralph Bown, former Bell Laboratories scientist.

An entertaining program of tours, fashion shows and matinees has also been arranged for wives of visitors.

— *m w j* —

PRD ANNOUNCES EXECUTIVE APPOINTMENTS

Two executive appointments have been announced by Henry H. Michaels, Jr., president of PRD Electronics, Inc., Brooklyn, N. Y. Promoted to new positions are Thomas H. O'Brien, director of operations, and Harry C. Nelson, director of marketing.

Before his new appointment, O'Brien served as director of product planning. Prior to 1959 he was associated with Sperry Gyroscope Company as engineering department head in charge of field test equipment and instrumentation. O'Brien will be responsible for the engineering, manufacturing, and special project activities at PRD.

Mr. Nelson, with PRD since 1948, has served as sales manager. From 1942 to 1948 he was a member of the staff of the Microwave Research Institute of the Polytechnic Institute of Brooklyn. Nelson will be responsible for the sales, marketing, advertising, promotion, and applications engineering activities at PRD.

— *m w j* —

(Continued on page 76)

QUIET PLEASE!

Electrons faithfully obey this command in their movements between brush and ring in Electro-Tec slip-ring assemblies. Materials are so carefully selected, precious metals so accurately deposited and machined, and design so skillfully integrated, ETC slip-ring assemblies transfer electrons in hushed electrical silence.

Do you have an electrical noise problem in radar, fire-control, inertial platforms or any other type of moving equipment? Learn how the electrical silence of an ETC slip ring can add accuracy and reliability to your system.

Write today for the new ETC brochure on large slip-ring assemblies.

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WEINSCHEL

ANTENNA PATTERN ANALYZER MODEL BA-7

Measure 45 db (r. f.) in one step using a maximum of 1 microwatt r. f. power*

*100% square wave modulated at 1000 cps ± .1 cps. Observation time approximately 45 seconds for 45 db; only .2 seconds for 30 db.

Bandwidth variable from 2 to 15 cps with constant gain

MODEL BA-7

The BA-7 is the heart of a video detector system designed primarily for r. f. crystals. For greater versatility, a d. c. biasing circuit is included to permit use of conventional barretters, requiring a d. c. bias between 0 and 10 ma. The unit can be used to measure very high power ratios such as occur in making antenna pattern measurements, to determine the reflection coefficients of r. f. filters, and to calibrate attenuators. It has a wide dynamic linear range, a low noise level, and a wide r. f. frequency range where video crystal mounts are available.

For complete specifications, write for Bulletin No. 141.

Weinschel Fixed Coaxial Attenuators cover the frequency range of DC to 12.4 KMC. Write for complete catalog, specifying frequency range of interest.

WE CO

Weinschel Engineering
KENSINGTON, MARYLAND

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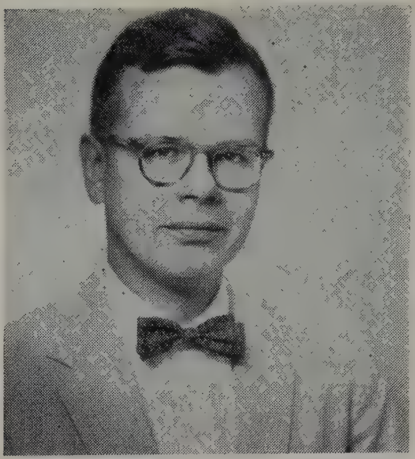
(Continued from page 75)

WTA APPOINTS BACON



The appointment of Edward J. Bacon as Head of the Electronics Department has been announced by Washington Technological Associates, Rockville, Md.

Bacon comes to WTA directly from Emerson Research Laboratories, and was earlier employed at Diamond Ordnance Fuze Laboratories and Radio Corporation of America. He earned both his BS (1946) and MS (1947) degrees in Electrical Engineering at Massachusetts Institute of Technology.

While Chief of the Air-Target Fuzing Section at Diamond Ordnance Fuze Laboratories, he guided the development and fabrication of proximity fuzing systems for the Terrier, Sparrow and Tartar missiles, and was successful in improving fuze performance for increased reliability, immunity to countermeasures and absolute range cut-off.

Bacon is a senior member of the Institute of Radio Engineers.

—mwj—

AEL ANNOUNCES APPOINTMENTS

American Electronic Laboratories, Inc., Philadelphia, Pa., has announced the appointment by the Board of Directors of a senior vice president and two vice presidents.

Conrad J. Fowler has been named senior vice president and retains his position as chairman of the Board. He is one of the original founders of AEL. Raymond S. Markowitz and Milton Nussbaum have been appointed vice presidents.

A graduate of the Moore School of Electrical Engineering of the University of Pennsylvania, Mr. Markowitz received his MS degree in electrical engineering in 1952. Mr. Markowitz is in charge of the Equipment Division of AEL. His group is responsible for work in UHF Communication Equipment. He participated in early development of citizens radio communication equipment, Loran, and in the development of UHF receivers for Military Airborne Television. A professional engineer registered in the state of Pennsylvania, Mr. Markowitz is a member of Sigma Tau and the IRE. Prior to his joining AEL in 1953, he was engaged in research and development engineering for the Philco Corporation.

Mr. Nussbaum received his MS degree in electrical engineering from the Moore School of Electrical Engineering of the University of Pennsylvania in 1953. Mr. Nussbaum heads the Component Division of AEL. He is responsible for Microwave and Antenna System Research and Development. Mr. Nussbaum has been instrumental in the development of a wide variety of antennas and antenna systems. He holds patents covering antenna design. Mr. Nussbaum is a member of the IRE and the Professional Group on Antennas and Propagation. Mr. Nussbaum was with Remington Rand Univac prior to his joining AEL in 1952.

—mwj—

ATLAS ENGINEERING ANNOUNCES CONSTRUCTION OF NEW PLANT

Norman Scotch, vice president of the Atlas Engineering Co., Inc., Roxbury, Mass., announces the construction of a new, ultra-modern plant to be located at 10 Cheney st., Roxbury, Mass. The completion date is scheduled for early February, 1961.

These new facilities will include 36,000 square feet of manufacturing area.

—mwj—

GOMBOS APPOINTS DePAOLA

John Gombos, president of John Gombos Co., Inc., Clifton, N. J., has announced the appointment of Mr. Gino E. DePaola, New Shrewsbury, N. J., as Senior Staff Engineer. He will be responsible for the advanced design and development of microwave filters as well as active cavities, thus greatly expanding the scope of existing facilities in their microwave component line.

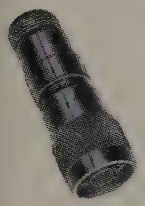
Mr. DePaola was formerly associated as Chief Engineer of Prode-line and Frequency Standards. He was also Senior Engineer, responsible for Advanced Antenna design and development. He is a graduate of Newark College of Engineering and is continuing his education at Stevens Institute.

—mwj—

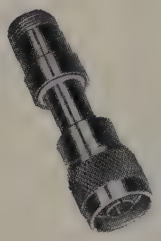
(Continued on page 78)

FIXED ATTENUATORS FROM STOCK FREQUENCY RANGES DC TO 12 KMC.

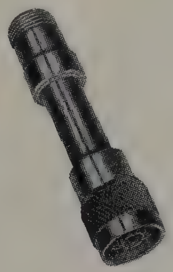
FROM OVER 7000 STOCK MICROWAVE COMPONENTS, MICROLAB NOW HAS AVAILABLE FIVE SERIES OF FIXED ATTENUATORS FOR IMMEDIATE ELIVERY WITH THE WIDEST CHOICE OF CONNECTORS AND ATTENUATION VALUES



SERIES
ecommended for component
d laboratory use from DC to
00 mc, the AA series atten-
tors are low cost, miniatur-
ed, fixed pads. Units are
nstructed of resistive ele-
ents in conventional pi type
rcuits. They are bi-directional,
ceptionally rugged, water-
oof, and negligibly affected
temperature and humidity
anges. The PA series is iden-
cal except for a 72 ohm
aracteristic impedance.



AB SERIES
Designed for use in the DC to 5000 mc region, these units are exceptionally stable, bi-directional, and unaffected by temperature and humidity changes. The units are constructed of Microlab film resistors in conventional tee circuits. Operation to 5000 mc is possible due to the ultra-miniaturized resistors and advanced impedance matching techniques employed.



AC SERIES
These series of attenuators are miniaturized attenuation standards designed for use in the 4000 to 12000 mc region. Exceptionally stable and bi-directional, their small size and rugged mechanical properties provide a valuable component for systems applications. The units consist of a distributed lossy line contained within a coaxial housing.

AD SERIES
These attenuators are miniaturized medium power units designed for use in the DC to 4000 mc region. They are conservatively rated for a 15 watt power input under all specified environmental conditions. Units consist of two or more lumped tee sections cascaded to distribute the power dissipation. Cooling fins minimize the temperature rise.

FIXED ATTENUATORS

MICROLAB SERIES	AA	AB	AC	AD	PA
FREQUENCY RANGE (kmc)	0-3	0-5	4-12	0-4	0-3
ATTENUATION VALUES (db)	0-60	0-60	0-20	0-60	0-60
MAXIMUM VSWR	1.20	1.20	1.30	1.20	1.20
IMPEDANCE (ohms)	50	50	50	50	72
ACCURACY (db) (1)	—0.5 +1.2	—0.5 +0.5	—0.5 +0.5	—0.5 +1.0	—0.5 +1.2
POWER, AVERAGE (watts)	2	2	2	15	2
POWER, PEAK (kw)	2	3	3	3	2
OVERALL LENGTH (in) (1) (2)	2.2	2.7	3.2	5.1	2.2
WEIGHT (oz) (1) (2)	2.4	2.8	2.9	4.8	2.4
WATERPROOF	yes	yes	yes	yes	yes

Notes: (1) 10 db nominal (2) Type N connectors (3) All of the above are available with Types N, BNC, TNC, C and HN connectors

MICROLAB

570
W. Mt. Pleasant
Avenue
Livingston, N. J.
WYman 2-5700

Circle Reader Service Card 38

MICROWAVE
SWITCH

TYPES FROM TRANSCO

Transco manufactures the most complete line of microwave switches, coax and waveguide (19 different types), for all frequencies including P, L, S, C, X and K band and many variations—solenoid and motor actuators, SPST to SP6T, DPDT, transfer, 4 actuator voltages, 8 RF connector types, high and low power. All switches have excellent RF characteristics and are built to military specifications. For information on the 19 types, or "type number 20" for your specific application, write or call Transco Products, Inc., 12210 Nebraska Avenue, Los Angeles 25, California, BRadshaw 2-5687. Application engineers and representatives throughout the United States and Canada.

TRANSCO

COAXIAL SWITCHES • WAVEGUIDE SWITCHES • ANTENNAS • MICROWAVE COMPONENTS • VALVES • ACTUATORS

Circle Reader Service Card 39

Industry News

(Continued from page 76)

HUGHES AIRCRAFT NAMES MUELLER TO NEW POSITION

Dr. William M. Mueller has been a pointed assistant manager of manufactu ing for the Hughes Aircraft Compan microwave tube division, Los Ange Cal., William H. Christoffers, manuf turing manager, has announced.

In addition to management responsibi ties involving microwave tube producti Dr. Mueller will be in charge of spe development projects in the manufactur department.

Dr. Mueller formerly was a memb of the technical staff of the Hughes R search Laboratories in Malibu, C Before joining the company in 1956, was engaged in microwave tube resear work at the University of Californ Microwave Laboratory and the Electroni Research Laboratory. He received his degree in 1950 from the University California and his PhD degree from th same university in 1958.

—*mwj*—

BOMAC'S McCARTHY ELEVATED TO CHAIRMAN

The board of directors of Bomac La oratories, Beverly, Mass., has elevate President Henry J. McCarthy to chairma of the board and named Executive Vi President Harold C. Booth to succeed hi as president.

Bomac, a subsidiary of Varian Asso ates of Palo Alto, Calif., manufactur microwave switching tubes, magnetron silicon diodes and duplexers used in rad applications.

Founded in 1947 by McCarthy an Booth, Bomac started with eight emplo ees in a 1500 square foot building. Tod it employs 600 workers and recent began construction of a 20,000 squa foot research and development buildin

—*mwj*—

VARIAN ASSOCIATES AND EASTER INDUSTRIES, INC. PROPOSE MERGE

The Board of Directors of Varia Associates and Eastern Industries, Inc have announced that they have arrived a preliminary basis for the merger Eastern into Varian. The present plan that one share of Varian would be issue in exchange for three shares of Easter It is expected that when all legal matter have been worked out the merger pla will be submitted to shareholders of bot companies at postponed annual meeting to be held in March 1961.

Eastern is a manufacturer of electroni traffic control equipment, environment control systems, high precision pumps an hydraulic control mechanisms, with hea quarters at Hamden, Conn. Varian is manufacturer of microwave tubes, com ponents and systems, scientific instru ments, high vacuum pumps and system and high energy devices, with hea quarters at Palo Alto, Cal.

—*mwj*—

(Continued on page 80)

S POWER STABILITY A REQUIREMENT FOR PARAMETRIC PUMPS?

by IRVING R. VERSOY
Engineering Manager, Instrument Division
LABORATORY FOR ELECTRONICS, INC.

arametric Amplifiers, in contrast to con- entional or transistor amplifiers, utilize A-C ources of power rather than D-C sources. hese A-C power supplies are commonly alled pumps and the operation of the nplifier depends on converting some of the ump energy into signal energy.

here are two main requirements for any nplifier; that it have a stable gain characristic, and that it introduce into the system o more than the absolute minimum of oise. Examination of these two design ctors indicates that the power source of the nplifier must have specific characteristics. onsidering the requirements of the paraietric amplifier, we find that the pump must ave both power and frequency stability for ptimum results.

versimplified, the effect of pump power on arametric amplifier gain can be compared to e effect of varying the B+ supply of a more onventional amplifier and indeed, within mits, variation of pump power can be used an amplifier gain control. A typical curve pump power vs amplifier gain is shown figure 1.

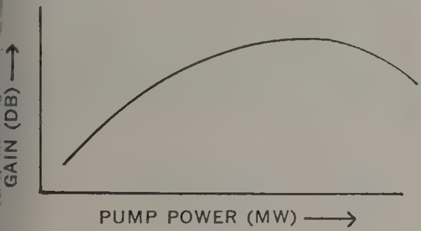


Figure 1

rom this figure it is obvious that optimum ump power is required for maximum gain, nd also that slight variations in pump power an have a significant effect on amplifier ain.

he noise figure of a parametric amplifier is iven approximately by:

$$NF = 10 \log \left(1 + \frac{\omega_1}{\omega_2}\right)$$

Where ω_1 = signal frequency
ω_2 = idler frequency

dditionally the pump frequency, ω_3 is elated to ω_1 and ω_2 by the following ossible relations.

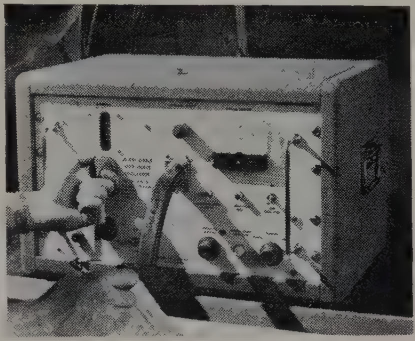
$$\omega_3 = \omega_2 - \omega_1$$
$$\omega_3 = \omega_2 + \omega_1$$
$$\omega_3 = \omega_1 - \omega_2$$

the case where $\omega_1 = \omega_2$, the minimum chievable noise figure is 3 db. However, hen $\omega_2 >> \omega_1$, the noise figure can become etter than 1 db.

or this reason, it is generally taken as a uide figure that ω_2 = 4 to 6 ω_1. For wer frequency, amplifiers UHF through band, the X-Band pump is chosen. At higher frequencies, a compromise must be made between available power sources and minimum noise figure.

So far, little has been said concerning the requirement for frequency stability of the pump. This occurs because the bandwidth of the amplifier is a function of the idler circuit Q; the higher the Q, the narrower the bandwidth. Increase of bandwidth can be attained only at the expense of more pump power. It is, therefore, very desirable to be able to set the pump on frequency and forget it, particularly if the pump power is also stable.

LFE's Model 814 series of Stable Microwave Oscillators are ideally suited to attaining the ultimate in both stable gain and pass band.



Here are the pertinent specifications:

Frequency:
Short-term stability
5 parts in 10^8 peak deviation
(i.e. 500 cycles peak @ 10 kmc)
Long-term stability 1 part in 10^6 per hour
Power Stability
At any set frequency
± 0.25 db/hour into a constant load

These figures are based on normal environmental conditions.

Short-term frequency stability implies a period of time. Actually, however, our definition is the measure of periodic or transient perturbations that take place about the operating frequency, F_O, over a disturbance or modulating frequency band of 15 c/s to 10 kc/s.

This is determined by the response characteristic of the metering amplifier in the stability tester used, the LFE Model 5009. This corresponds to an averaging period of a minimum of 100 microseconds and a maximum of 0.066 seconds. As a matter of interest, noise, a non-periodic function, introduces the greatest amount of fm residual. As expected, the principal periodic contribution is from power line frequencies.

Long-term drift is brought about almost equally by variations in temperature and humidity, and drift of the D-C amplifier. The components most affected are the invar dual-mode discriminator cavity, and the diodes associated with it. The specification figure is a maximum to be expected over a period of one hour under usual environmental conditions.

In the 814 Series, there are only two primary operating controls, the main one is directly calibrated in frequency to ±0.1%. Loss of stabilization is signalled by a warning light. An additional feature of the 814 Series is a built-in 1 kc AM modulator, with provision for FM modulation by an external modulator. Wherever frequency and power stability really count, you can count on LFE's Stable Microwave Oscillators.

SIGNIFICANT USES:

- Maser and parametric amplifier pumps
- MTI laboratory and production tests
- Secondary microwave frequency standards
- Microwave spectroscopy
- Backscatter measurements
- Q measurements
- Simplified dielectric constant and tangential loss measurements.

SERIES 814
STANDARD MICROWAVE
OSCILLATOR LINE

Oscillator	Frequency in mc/s	Nominal Power (milliwatts)
S-BAND		
814-S-1 814-S-2 814-S-31	2500-3050 2950-3600 3700-4300	75 80 1
C-BAND		
814-C-1A 814-C-10 814-C-31	5100-5900 5400-5900 5925-6425	60 200 1
X-BAND		
814-X-1 814-X-2 814-X-21	8500-10,000 9000-10,500 8500-10,000	80 55 500
K-BAND		
814-K-21 814-K-22 817-K-25	12,400-14,000 14,500-17,500 24,000-27,000	100 100 40

In addition to the standard models whose power and frequency ranges are shown above, packaging and engineering modifications are available to meet the physical requirements of systems in which an 814 is a component. For Bulletin 814, or for particular information, write to Mr. Perry Pollins. If you are also interested in measuring stability, ask for a bulletin on the Model 5009 Stability Tester.

LABORATORY FOR ELECTRONICS, INC.
714 BEACON STREET, BOSTON

(Continued from page 78)

CARBONE WILL DIRECT PLASMA PHYSICS LABORATORIES

Nuclear Corporation of America, Denville, N. J., has announced that Dr. Robert Carbone has joined the Central Electronic Manufacturers as Director of the Plasma Physics Laboratories.

Previously, Dr. Carbone was with M.I.T. Lincoln Laboratories in Lexington, Mass., where he did research on gaseous discharge tubes with special emphasis on microwave devices. He holds a doctorate in Atomic Physics and has published many papers in atomic physics on scattering experiments.

Dr. Carbone brings with him Mr. Newell Clabo, his assistant, who also has worked on gaseous discharge tube techniques.

—*mwj*—

MAGID JOINS MICROWAVE DYNAMICS

Milton Magid has joined Microwave Dynamics Corp., Plainview, L. I., N. Y., a subsidiary of Talley Industries, Inc., as senior staff engineer, it has been announced by Neal Deoul, president.

He will be responsible for planning and execution of a program for development of a proprietory line of microwave components and instruments. Conception and development of these products will be aimed at advancing the state of the microwave art.

Mr. Magid was formerly head of Microwave Product Engineering at FXR, Inc., where he was responsible for microwave component and instrument quality by establishing improved measurement techniques and evaluating existing product performance. In addition, he contributed to new product development and initiated a standards laboratory program.

He is a senior member of the IRE, an associate member of RESA, and was elected to Eta Kappa Nu, Tau Beta Pi and Sigma Xi honorary societies while at the University of California at Berkeley.

Mr. Magid received his BS degree (with honors) from the University of California at Berkeley and his MS degree from UCLA.

EXECUTIVE REALIGNMENT ANNOUNCED BY MELPAR

Edward M. Bostick, executive vic president and general manager of Melpa Inc., Falls Church, Va., has announce the following organizational changes:

Charles B. Raybuck, vice president fc Research and Engineering, is named vic president for Contract Management.

Dr. Paul E. Ritt, director of the Physic Sciences Laboratory, is named director Research.

Robert S. Butts, chief engineer, w become technical advisor to the executiv vice president and general manager.

William C. Purple, Jr., vice preside for Production, is named vice preside for Engineering and Manufacturing.

—*mwj*—

CORNELL-DUBILIER TRANSFERS HEADQUARTERS

Cornell-Dubilier Electronics division c Federal Pacific Electric Company is tran ferring its corporate headquarters t Newark, N. J., while some manufacturin operations will remain in South Plainfield N. J., it has been announced by Octav Blake, Cornell-Dubilier President.

The South Plainfield plant will b operated as part of Federal Pacific's Eas ern Manufacturing Group under th direction of J. T. Romano. L. Stiegelmaye continues as the Plant Manager and H. C Craig is Engineering Manager.

Cornell-Dubilier Electric Corp. with i 6 plants became a part of the Feder Pacific organization in March 1960.

—*mwj*—

LITTON WILL SUPPLY POWER PACKS TO TAPPAN

Litton Industries has entered an agre ment to supply magnetron-type electro tube power packs to The Tappan Com pany for household electronic range according to Dr. Norman H. Moor vice-president and general manager Litton's Electron Tube Division, Sa Carlos, Cal.

The new magnetron, especially suitab for radio frequency food preparation, the result of two years development.

—*mwj*—

FXR, ELLIOTT SIGN LICENSING AGREEMENT

FXR, Inc., Woodside, N. Y., manufac turer of microwave test instruments an associated equipment, has signed a mutua licensing agreement with the 160-year-ol English firm of Elliott Brothers, (London Ltd., a subsidiary of the Elliott-Automa tion Ltd., Tore N. Anderson, presiden of FXR, has announced.

Marking FXR's first major oversea step, the agreement gives FXR and Ellio exclusive rights to make and sell th other's full range of microwave instru ments and components. Elliott's territor under the agreement, comprises all of th British Commonwealth except for Canada FXR's, the United States, its overseas possessions and Canada.

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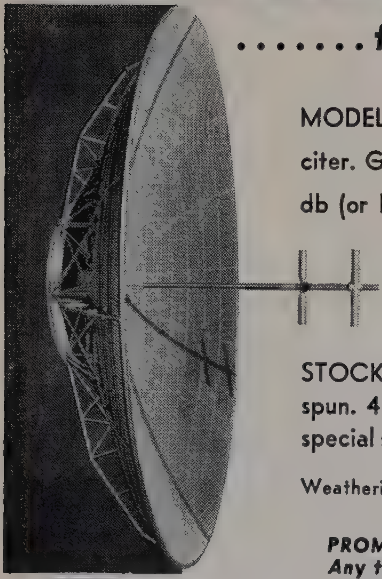
(Continued on page 82)

AINSLIE ANTENNAS



.......for the 100-500 mc BAND

MODEL CF121M — 12 ft. diameter with dipole exciter. Gain 23 db at 500 mc. Minimum side lobes 20 db (or better). Cross Polarization 20 db (or better).

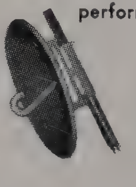
Low VSWR at any frequency in the band. Accomplished through adjustable balun and reflector assembly.

STOCK REFLECTORS—4 in. to 10 ft. diameter solid spun. 4 ft. to 18 ft. diameter mesh. Larger sizes or special shapes on request. Antennas up to 10,000 mc.

Weatherized & corrosion resistant. Rugged, lightweight.

PROMPT DELIVERY
Any type antenna or reflector for precision-built to your specifications.

Write for complete performance data sheets.



MODEL CF141M with 14' diameter reflector available

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CORPORATION

531 POND STREET, SO. BRAINTREE 85, MASSACHUSETTS

Designers & Manufacturers of Microwave Antennas & Associated Equipment

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Bendix Craftsmanship at work for you

TWO-67
MADE IN U.S.A.
Bendix

AVAILABLE TYPES

Solenoid Focused

Type TWO-88 with frequency range of 30 KMC to 40 KMC
Type TWO-75 with frequency range of 40 KMC to 50 KMC
Type TWO-67 with frequency range of 49 KMC to 59 KMC
Type TWO-82 with frequency range of 50 KMC to 60 KMC
Type TWO-66 with frequency range of 61 KMC to 71 KMC
Type TWO-83 with frequency range of 65 KMC to 75 KMC
Type TWO-85 with frequency range of 70 KMC to 85 KMC
Type TWO-87 with frequency range of 85 KMC to 100 KMC
Type TWO-90 with frequency range of 100 KMC to 120 KMC

AVAILABLE NOW PERMANENT MAGNET FOCUSED TYPE TWO-89 WITH FREQUENCY RANGE OF 50 KMC TO 60 KMC

LARGEST LINE OF MILLIMETER WAVE LENGTH BWO

Bendix® BWO tubes for higher frequency transmission. These Backward-Wave Oscillator Tubes—exclusive with Bendix—generate microwave energy over the largest continuous frequency range. Ideal for advanced multichannel telephone and television systems, microwave spectroscopy, high definition short range radar, highly directive communications, and many other applications needing low power, voltage-tuned millimeter wave length radio frequency energy. Write today for complete information.

ELECTRICAL DATA

requency Range	30 KMC-120 KMC (see specific type)
node Voltage	1000-4000 volts
ower Output	Up to 20 mw average (depending on frequency)
eam Current	10 MA
agnetic Field	2000 gauss
eater Voltage	6.3 ±10%

MECHANICAL DATA

Output Flange	Special adapter to RG-98/U (50-75 KMC)
Maximum Diameter	0.625"
Length	8"
Mounting Position	Any
Weight	5 oz.*

*Without magnet (tube only). Magnets are available.

ELECTRON TUBE PRODUCTS

Red Bank Division
EATONTOWN, NEW JERSEY

THE Bendix CORPORATION

TRANSISTORIZED POWER BRIDGE

measure microwave power directly, quickly, accurately

The AIL Type 50 R-F Power Bridge applies the most advanced transistor circuitry techniques to power measurements in the 10-40,000 Mc range. Full scale ranges of 1.0 and 10 milliwatts and plus and minus 10dbm are provided. Accuracy within 0.5 db.

Compact—battery operated—weighs less than 4 pounds—hand held—ideal for field applications.

Each Type 50 is carefully checked and tested under the rigid AIL quality control system assuring highest reliability for a variety of applications in:

Radar • Communications
Navigation • Telemetering
Television • Transmission lines
Microwave links • R-F leakage

Price *$199*
Write for details

AIRBORNE INSTRUMENTS LABORATORY
DEER PARK, LONG ISLAND, NEW YORK
A DIVISION OF CUTLER-HAMMER, INC.

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(Continued from page 80)

HURLEY APPOINTED GENERAL MANAGER

The directors of Harvard Industries, Inc., have announced the appointment of William D. Hurley as general manager of the company's Frequency Standards division, Asbury Park, N. J. Hurley was also elected a vice president of Harvard Industries and member of the board.

Hurley, who received the MS degree in Engineering from Stevens Institute of Technology in Hoboken, N. J., was formerly assistant to the president of Lockheed Electronics Company, Plainfield, N. J. As general manager of Frequency Standards he plans to strengthen the company's position in electronics through an aggressive product development and marketing program.

—m w j—

SYLVANIA AWARDED $7.5 MILLION CONTRACT FOR MINUTEMAN MISSILE COMMUNICATION SUB-SYSTEM

Receipt of a $7.5 million contract for development and engineering of the command communication sub-system of the radio launch control system for the Air Force's Minuteman intercontinental ballistic missile is announced by Sylvania Electric Products Inc., Buffalo, N. Y.

H. C. Tittle, general manager of the Buffalo Operations of Sylvania Electronic Systems, said the award was received from the Aero-Space division of Boeing Airplane Company, Seattle, Wash., associate contractor for the assembly and test portion of the Minuteman program.

The Minuteman is a three-stage solid-propellant ICBM with a range of more than 6000 miles. It is being developed under the direction of the Air Force Ballistic Missile Division, Air Research and Development Command.

Minuteman missiles will be stored in concrete blast-resistant underground launch silos. They will be ready for immediate retaliation in the event of attack.

Mr. Tittle said the command communication sub-system, for which Sylvania is responsible, will provide for highly reliable transmission of commands from the Minuteman launch control facilities to the silo-stored missiles and, simultaneously, to all other launch control facilities in the missile squadron.

In addition, the sub-system will provide for anti-jam, tactical communications between the various launch control facilities on a time-shared basis.

Development of the sub-system will be carried out at the Amherst Laboratories of the Buffalo Operations, Mr. Tittle said, and prototype production will be done at the Operations' Systems plant. George L. Downs will serve as program manager and Robert D. Gray as technical program manager of the program.

—m w j—

THREE APPOINTED TO KEY POSITIONS IN RCA MICROWAVE DEPARTMENT

Walter C. Byrne, Jr., has been appointed manager for Microwave Marketing, it was announced by J. J. Graham, Division vice president and general manager, Communications and Controls Division, Radio Corporation of America.

Mr. Graham at the same time said that Haddon S. Wilson has been named Custom Microwave project manager and Norman E. Edwards, manager, Microwave Engineering. Byrne, Wilson, and Edwards will report to Edward J. Hart, recently designated manager of RCA's expanding Microwave Department.

Mr. Byrne, who formerly was associated with the Hallicrafters Company and Motorola, Inc., obtained degrees in mechanical engineering and electrical engineering at Tulane University. He also did advanced research at Tulane.

—m w j—

HELICOPTER RADAR TRACKS SUB PERISCOPES

A helicopter radar system designed to seek out submarine periscopes and snorkel tubes is under development in North Hollywood, Cal., it has been announced by The Bendix Corp.

As a further expansion of its anti-submarine warfare program, the Bendix-Pacific division will produce two prototype surface search-navigation radar systems for the Navy's Sikorsky HSS-2 helicopters, according to the company.

The radar, a result of development done by Bendix-Pacific for the Office of Naval Research, will boost the HSS-2 weapon system's ASW capabilities by pinpointing any portion of a submarine showing above the sea's surface, Bendix engineers report.

Sikorsky division of the United Aircraft Corporation also has ordered additional quantities of the Bendix-Pacific AQS-10 sub-search sonar equipment, first announced in October, 1959. The "3-D" — dip, detect and destroy — system makes it possible for the HSS-2 helicopters to cover undersea search areas substantially larger than those previously blanketed by "dunking" sonar.

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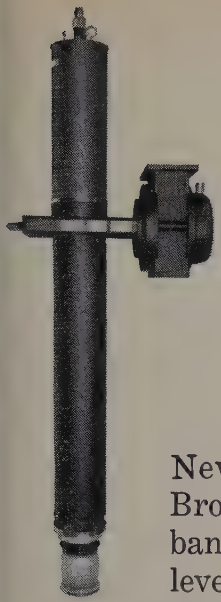
(Continued on page 84)



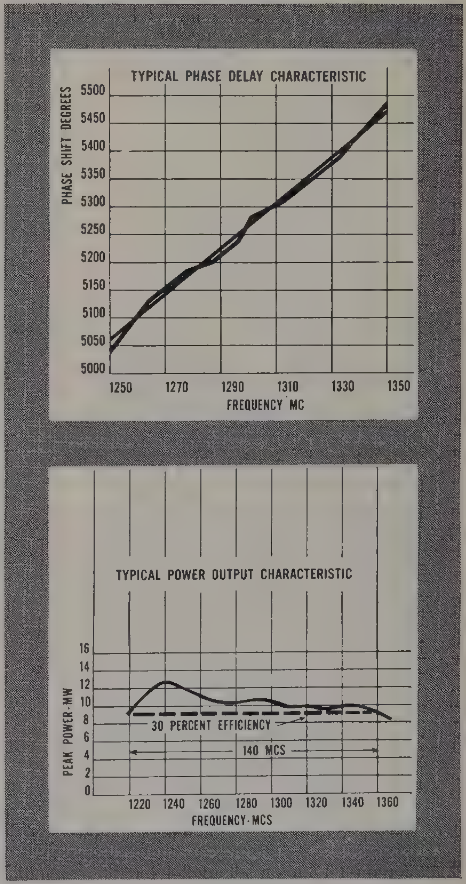
New Broadband Klystrons

140 MEGACYCLES - (1db) BANDWIDTH AT L-BAND
10 MEGAWATTS - PEAK POWER OUTPUT

New additions to the Litton Industries Broadband Klystron family extend broadband performance to even higher power levels as shown in the typical performance curves to the right. These tubes, like all those produced by Litton Industries, are conservatively designed and rated; and rigorously processed to provide many thousands of hours of reliable operation. Using Litton developed broadbanding techniques, it is now possible to achieve wide bandwith, high peak and average rf power output and linear phase shift versus frequency characteristics simultaneously. This latter feature enables the radar equipment designer to utilize pulse compression techniques to attain improved system performance.

Litton Klystrons providing these outstanding performance characteristics can be supplied in both the L and S-bands at peak rf power levels ranging from 2 to 20 megawatts. Typical of the performance obtained with Litton Klystrons is that of the L-3035, a 2.2 megawatt L-band Klystron, whose average operating life in field service is approaching 3,000 hours. Some of these tubes are continuing to provide excellent service after having operated for more than *17,000* hours.

Should you require high power broadband amplifier tubes to satisfy your system requirements, please write to us at Litton Industries, Electron Tube Division, 960 Industrial Road, San Carlos, California. Our telephone number is LYtell 1-8411.



LITTON INDUSTRIES
Electron Tube Division
MICROWAVE TUBES AND DISPLAY DEVICES

"Capability that can change your planning"

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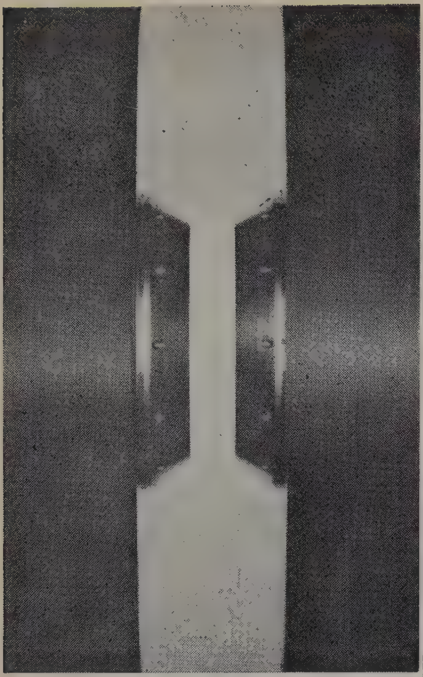
(Continued from page 82)



NEW 32-page brochure...

LABORATORY MAGNETS

Your copy of Varian's new brochure on the complete line of Varian laboratory magnets will be mailed upon request.

VARIAN MAGNETS

- DESCRIPTIONS
- SPECIFICATIONS
- FIELD DATA
- PERFORMANCE
- ACCESSORIES

Write Instrument Division

VARIAN associates
PALO ALTO 34, CALIFORNIA

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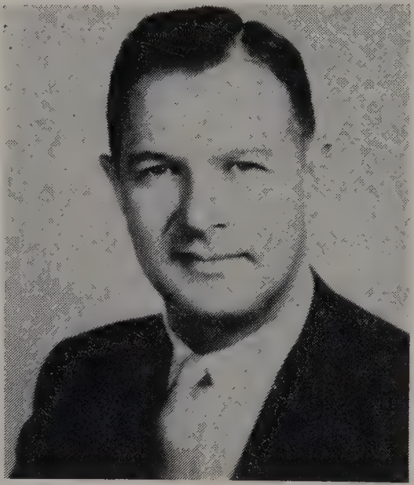
MICROWAVE APPLICATIONS ENGINEERING ORGANIZATION ESTABLISHED

Bertram D. Aaron, PE, has announced the reorganization and expansion of his field-engineering and management consulting activities into Bertram D. Aaron & Co., Long Island, N. Y.

Since 1943, Mr. Aaron has specialized in microwave theory and applications, for the past eight years as manufacturer's representative for Bomac Laboratories, Inc., and other firms, first in the Los Angeles region and more recently in the New York City Metropolitan area. Bertram D. Aaron & Co., will continue to concentrate on microwave applications but will also handle other compatible types of electronic equipment over an expanded territory that will include northern New Jersey and Long Island, as well as the New York Metropolitan area.

Mr. Aaron, who took his EE degree at Virginia Polytechnic Institute, and spent several years in the U. S. Army Signal Corps and the NACA (now the NASA) at Langley Field, Va., is perhaps best known to those in the microwave field for his work as Secretary in charge of the Defense Procurement Agency's Integration Committee on Hydrogen Thyratrons — commonly known as the Hydrogen Thyratron Council. For the Signal Corps Mr. Aaron directed several programs which set up production facilities for special types of film and certain military electronic equipment. Mr. Aaron is a senior member of the IRE, and is at present chairman of the Long Island chapter's Professional Group on Microwave Theory and Techniques.



—*mwj*—

POLYTECHNIC INSTITUTE AWARDED $375,000 GRANT BY NATIONAL SCIENCE FOUNDATION

Polytechnic Institute of Brooklyn, Brooklyn, N. Y., has been awarded a grant of $375,000 by the National Science Foundation to support the construction of graduate level research laboratories, it was announced by Dr. Ernst Weber, Polytechnic president.

The laboratories will be established in Polytechnic's Long Island Graduate Center, now under construction in Farmingdale. Located on Route 110, a half-mile east of the Nassau-Suffolk line, the center is designed to provide graduate education and research in aeronautics, astronautics, electrical engineering, electrophysics, mechanical engineering, mathematics and physics.

The 25 acre site for the center was given to the Polytechnic by Republic Aviation Corporation.

The center, being established at a cost of $1,600,000, will consist of two buildings with a total of 65,000 square feet of floor space. The main building, a combination one and two story structure, will house nine classrooms, a science library for 20,000 volumes, administrative offices, dining area, lounge and meeting room.

Also, twelve laboratories for research in aero-space engineering, electrical engineering, physics and electrophysics will be housed here. The main building will contain 53,000 square feet of floor space.

The second building, a steel frame structure of 12,000 square feet, will house three laboratories for basic research in aerodynamics and high power electronics. The main building is scheduled for completion in September 1961 when classes will begin. The second building will be completed in March.

—*mwj*—

PIB SYMPOSIUM DUE ON ELECTROMAGNETICS AND FLUID DYNAMICS OF GASEOUS PLASMA

The eleventh annual international Polytechnic Institute of Brooklyn Symposium, scheduled for April 4-6, 1961 in New York City, will be devoted to "Electromagnetics and Fluid Dynamics of Gaseous Plasma".

The area of interest covers collective electromagnetic and fluid dynamic phenomena and their self-consistent analytical description in the temperature range characteristic of the transition between partially and fully ionized gaseous plasmas.

Typical of the subjects planned for discussion at the Symposium are Microscopic and Macroscopic Theories of Non-equilibrium Magneto-Fluidynamics, Linear Wave Propagation in Uniform and Non-Uniform Plasmas, Nonlinear Wave Propagation in Uniform and Non-Uniform Plasmas, and Possible Applications of Magneto-Fluidynamics.

This year the symposium is being organized by the Department of Aerospace Engineering and the Microwave Research Institute of the Polytechnic Institute of Brooklyn in cooperation with the Institute of Radio Engineers and the Institute of the Aeronautical Sciences and with the co-sponsorship of the Air Force Office of Scientific Research, the Office of Naval Research, and the U. S. Army Signal Corps.

—*mwj*—

INSTRUMENTS FOR INDUSTRY, INC. AWARDED TRANSMITTER SYSTEM CONTRACT

Instruments for Industry, Inc., has received a contract in excess of $100,000 for transmitter system development, according to an announcement by Elston H. Swanson, president. The Hicksville, N. Y. firm is an independent developer of electronic countermeasure systems and related components.

Received from Sanders Associates, Inc., Nashua, N. H., a contractor in the development of an electronic system for a U. S. Navy Bureau of Weapons system, the IFI contract involves advanced development in high power electronics, Mr. Swanson said.

—mwj—

WOENNE NAMED VICE PRESIDENT OF LITTON WORLD TRADE CORP.

Roy E. Woenne, manufacturing director of the Electron Tube Division, Litton Industries, San Carlos, Cal., has been named vice president and technical director of Litton World Trade Corporation, with headquarters in Zurich, Switzerland.

Announcement of Woenne's appointment was made by Charles B. Thornton, president and chairman of the board of Litton.

Woenne joined the original company bearing the Litton name as its first employee on May 1, 1935, while a student at San Mateo College. He has been the top manufacturing executive at the tube division for the last 10 years and also has been senior mechanical engineer, designing equipment and techniques for tube fabrication and assembly. Woenne has been active in the design and production of most Litton- developed vacuum tubes for radar, electronic countermeasures, missile and fire control and communications.

—mwj—

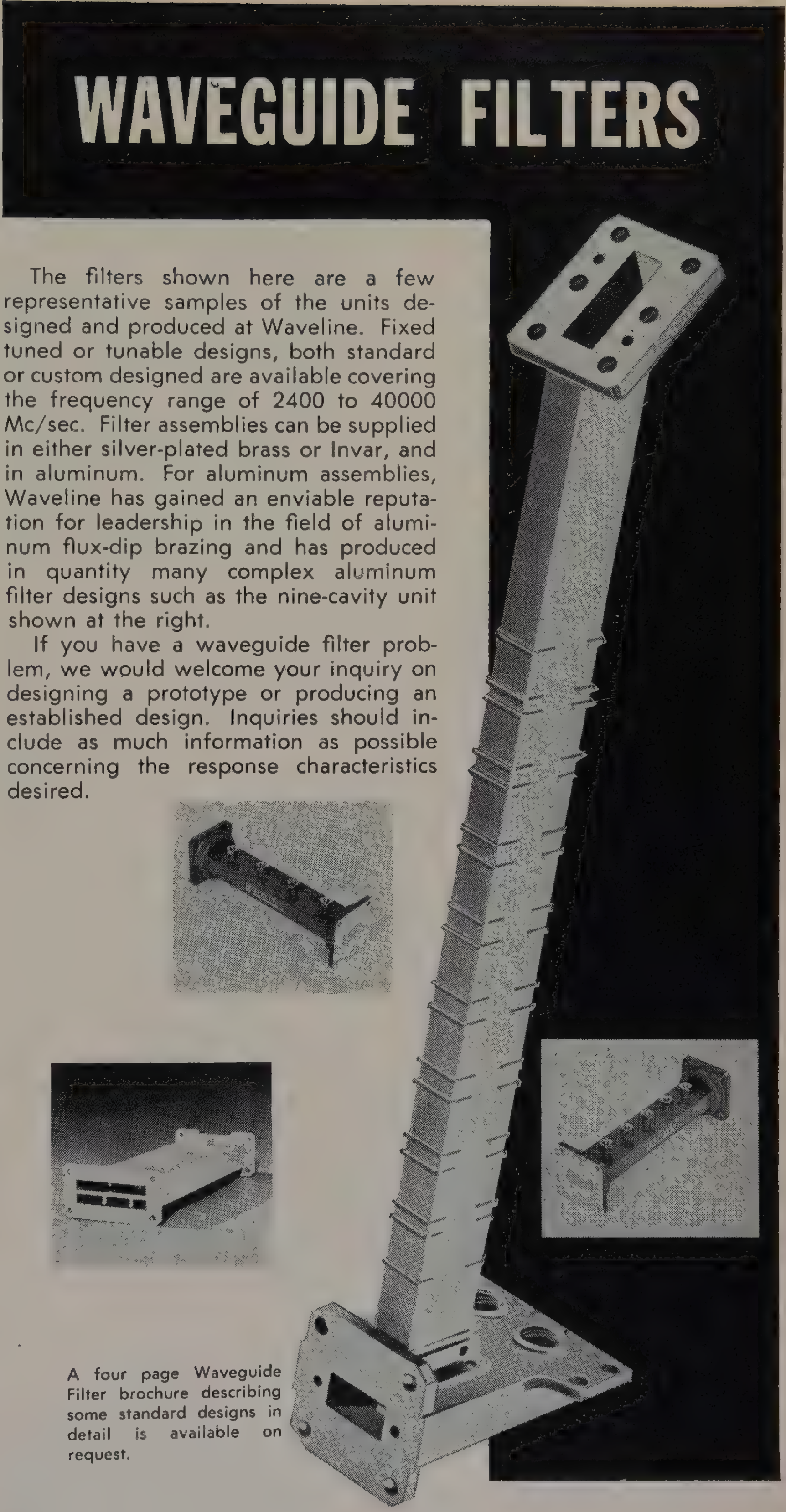
WHEELER NAMED GENERAL MANAGER AT INDIANA STEEL PRODUCTS

Portus M. Wheeler has been named vice president and general manager of Indiana Steel Products Division of Indiana General Corporation, Valparaiso, Ind. The appointment was made by Indiana General's Executive Vice President, John H. Bouwmeester.

Wheeler, who joined Indiana Steel in 1950 as a sales engineer in the Company's Chicago sales office, was promoted to regional sales manager in charge of the midwestern region sales staff in May, 1953. He assumed the responsibility of assistant sales manager in 1955 and was named sales manager in January, 1957. After the merger of General Ceramics Corporation into Indiana Steel in November, 1959, Wheeler was appointed Vice President-Sales for the Indiana Steel Products Division of I.G.C.

Prior to coming to Indiana Steel, he was a sales engineer for Chicago Viterous Company of Cicero, Ill. Wheeler is a graduate engineer of the University of Illinois and a member of the Sales Marketing Executives of Chicago.

—mwj—



WAVEGUIDE FILTERS

The filters shown here are a few representative samples of the units designed and produced at Waveline. Fixed tuned or tunable designs, both standard or custom designed are available covering the frequency range of 2400 to 40000 Mc/sec. Filter assemblies can be supplied in either silver-plated brass or Invar, and in aluminum. For aluminum assemblies, Waveline has gained an enviable reputation for leadership in the field of aluminum flux-dip brazing and has produced in quantity many complex aluminum filter designs such as the nine-cavity unit shown at the right.

If you have a waveguide filter problem, we would welcome your inquiry on designing a prototype or producing an established design. Inquiries should include as much information as possible concerning the response characteristics desired.

A four page Waveguide Filter brochure describing some standard designs in detail is available on request.

WAVELINE INC.
CALDWELL, NEW JERSEY

Circle Reader Service Card 45

New Products

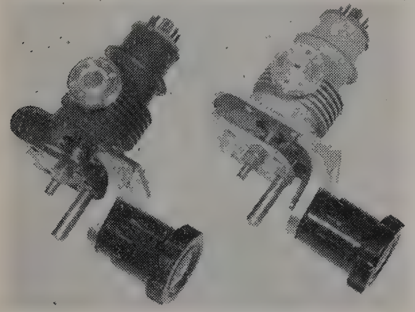
OKI ELECTRIC OFFERS FIRST JAPANESE-MADE REFLEX-TYPE KLYSTRON

The Oki Electric Co., Tokyo, Japan, has succeeded in manufacturing on a trial basis the first Japanese-made, 4 millimeter band reflex-type klystron.

A powerful signal source will become available in this band where formally frequencies of this type were always produced by the use of crystal multipliers.

The new klystron's shape is almost completely the same as the 50V10 which is already on the market. The wave guide is the WR-12 (RETMA) type. The cavity resonator and a reflector are small in proportion to the wave length and the tube was designed so that an electron beam with density of 50 A/cm^2 and 0.3 mm in diameter is produced.

The rating of the tube is cavity voltage, 3250V; cavity current, 30mA; heater voltage, 6.3V; control electrode voltage, —45V; reflector voltage, —50∼—300V; operating frequency range, 60∼75Gc, while output is several milliwatts. Test models have produced 20mW at 65Gc and the design of tubes of even higher output is possible. The electronic tuning range is approximately 150 Mc and the amount of hystersis is slight. Within the tuning range, output is steady. Because input is great, for a short period of time immediately after the tube is turned on, slight variations in the level of output and frequency occur, but after the tube has warmed up, performance is stable.



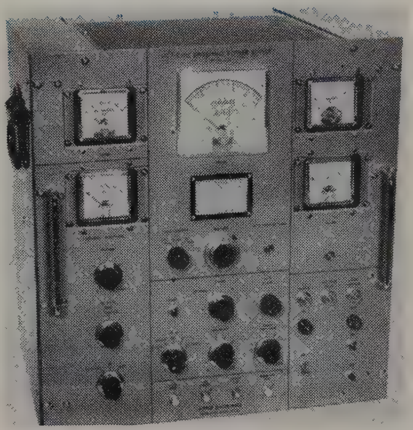
Circle Reader Service Card 100

—mwj—

SUPPLY DESIGNED FOR VOLTAGE TUNABLE MAGNETRONS

A new Sweeping Power Supply designed for operation of voltage tuned magnetrons is now available from Alfred Electronics, Palo Alto, Cal., manufacturer of broadband microwave instruments.

Alfred's model 610C Supply provides electronically swept operation either linear with time with repetition rates of 10 cps to .01 cps or non-linearly at 60 cps. Sweep voltage is available over the whole range or any part of the range. The unit may also be externally swept.



Voltage stability and low ripple voltage make model 610C a source for single frequency operation.

To make the unit compatible with other microwave test instrumentation, both the swept and unswept signal may be internally modulated with 800 to 1200 cps square wave. Protective circuits prevent damage from misadjustment or failures.

Key specifications: Anode (relative to chassis) —250 to —2500 v, sweep increases linearly with time; .02 per cent maximum pk to pk ripple and noise; Control electrode (relative to cathode) 0 to 900 v, 0 to 5 ma, .02 per cent pk to pk ripple above 50 v; Amplitude Modulation: external, DC operation; internal, 800 to 1200 cps square wave. Filament Supply, 0 to 6v DC at 0 to 4 amp.

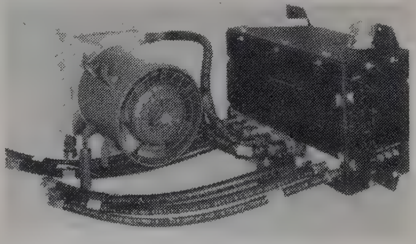
Circle Reader Service Card 101

—mwj—

COOLING UNITS USED IN GROUND SUPPORT EQUIPMENT

A line of airborne cooling units, modified for use in ground support equipment, is now being marketed by the Lear-Romec Division of Lear, Inc., Santa Monica, Cal., according to K. R. Hahn, executive vice president of the corporation.

High energy electronic equipment, Hahn explains, requires controlled heat dispersal for efficient and safe operation. With the increased complexity of aerospacecraft ground support equipment, size and weight requirements have become an important factor in cooling systems for ground based equipment. To meet these market requirements, compact, lightweight, airborne cooling units, similar to that produced by Lear for the Eagle Missile, will be developed for other than airborne application.



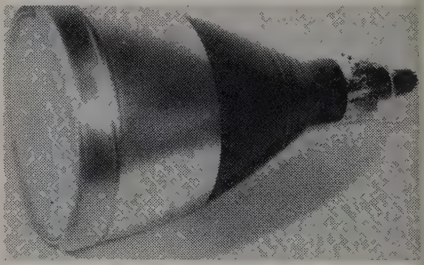
The Eagle Missile cooling unit is designed for cooling the missile's guidance system klystron amplifiers. This small Lear unit has a nominal heat dissipation rate of 9375 watts. Other Lear-Romec airborne liquid-to-air heat transfer systems, which are being developed for GSE applications, have cooling capacities of from 100 to 10,000 watts with operating temperatures in the —65° to 250° range.

Circle Reader Service Card 102

—mwj—

RADAR TUBE FEATURES LOW GRID DRIVE

A single-beam, fast writing cathode-ray tube with a 12 7/16 inch diameter face plate has been announced by the Electronic Tube Division, Allen B. Du Mont Laboratories, Divisions of Fairchild Camera and Instrument Corp., Clifton, N. J.



Registered as type 12AMP, the electrostatic focus and deflection 12-inch tube features a low drive electron gun which permits use of transistorized video circuitry. Post acceleration allows maximum deflection sensitivity with high overall accelerating voltages. Minimum spot defocusing is obtained, and the deflection plate connections are made through the neck of the tube to facilitate high frequency operation.

The tube screen is aluminized for greater light output and to minimize screen charging effects.

Circle Reader Service Card 103

—mwj—

SRL ANNOUNCES LINE OF PRECISION WAVEGUIDE GAGES

Somerset Radiation Laboratory, Inc., designers and manufacturers of precision microwave gaging instruments, offers Series O. D. precision waveguide gages for checking the outer dimensions of waveguides to MIL-W-85C and EIA Standards.

(Continued on page 88)

ALFRED ELECTRONICS MAKES THE INDUSTRY'S MOST ADVANCED

Swept Microwave Oscillator

No other sweeping oscillators offer as many solid advantages as Alfred Electronics' new series 620 models, built by the industry's leading manufacturer of high quality, broadband microwave instruments. Note these features:

★ **Five models, covering 1 to 18 kmc.** Broadest frequency range available. Electronic sweep of RF output, or extremely stable CW operation.

★ **Two adjustable frequency markers** for convenient calibration of oscilloscopes or recorders. Markers save valuable test time by indicating either band limits or intermediate frequency values. An exclusive Alfred feature on all models.

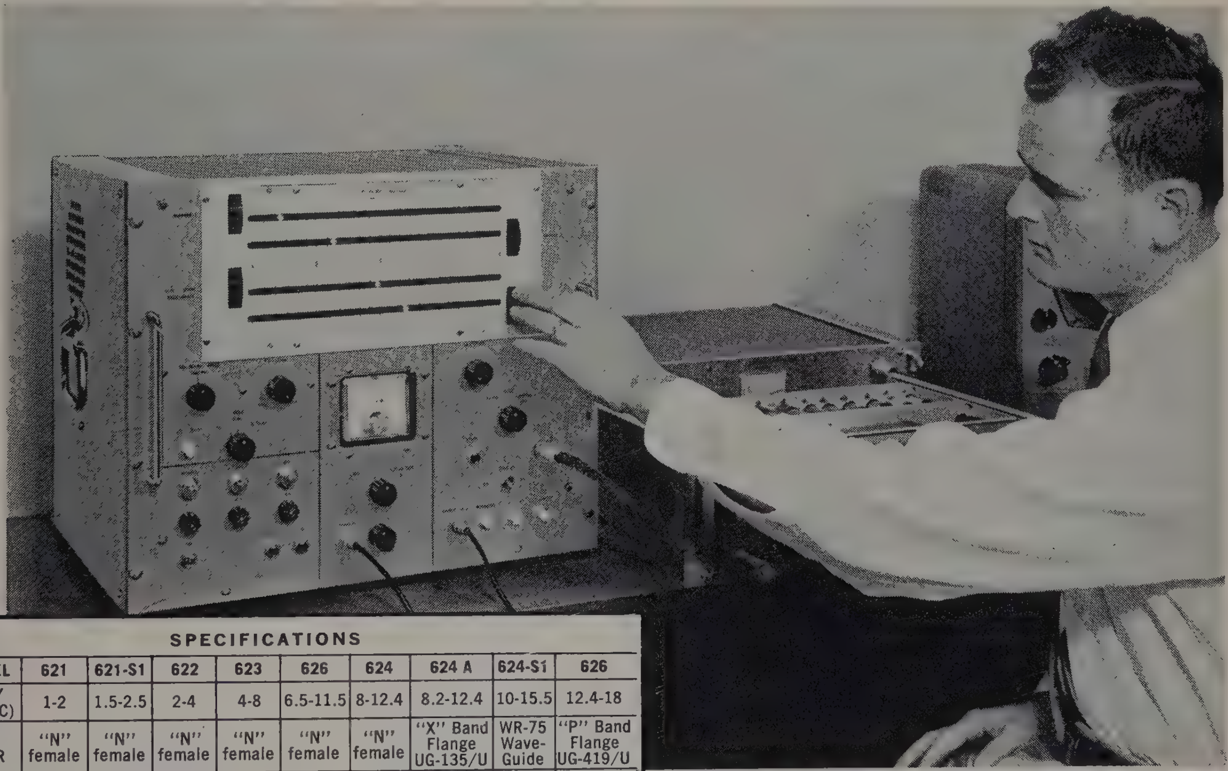
★ **Stable single frequency source.** Drift less than ±.02% per hours; residual FM less than ±.0025% peak.

★ **Linear frequency sweep coverage** over all or part of each band for rapid evaluation of reflection coefficient, gain, attenuation and other network transfer characteristics.

★ **0.5 microseconds rise and fall** response to AM—equivalent to a 2 megacycle band pass. Another exclusive Alfred feature.

★ **Quick Look readout.** See frequency range, markers and sweep time at a glance. No cumbersome calculating.

★ **Fast sweep** for flicker-free oscilloscope presentation; slow sweep for mechanical recorder operation.



Using Alfred Model 623 Microwave Oscillator (left) to test small signal and saturation gain of Model 503 Traveling Wave Tube Amplifier. Microwave Leveler, Alfred Model 704, holds power output from oscillator constant within ±1 db.

SPECIFICATIONS

MODEL	621	621-S1	622	623	626	624	624 A	624-S1	626
FREQUENCY RANGE (KMC)	1-2	1.5-2.5	2-4	4-8	6.5-11.5	8-12.4	8.2-12.4	10-15.5	12.4-18
RF OUTPUT CONNECTOR	"N" female	"N" female	"N" female	"N" female	"N" female	"N" female	"X" Band Flange UG-135/U	WR-75 Wave-Guide	"P" Band Flange UG-419/U
PRICE	$3090	$3190	$2990	$2890	$2990	$2890	$2890	$3290	$3340

GENERAL

FREQUENCY CONTROL: Continuously adjustable with direct calibrated dial. Calibration accuracy, 1%.

RESIDUAL FM: Less than ±.0025% peak.

DRIFT: Less than ±.02% per hour.

POWER OUTPUT (minimum): 10 mw. Continuously adjustable from zero to maximum.

VSWR (maximum): 2:1.

SWEEP

SELECTOR: Recurrent sweep, single sweep, CW, and external on panel switch.

CONTROL: Single sweep, triggered by panel button, or external positive going signal 20 volts or greater.

SWEEP WIDTH: Continuously adjustable from 0 to any part of entire frequency range.

TIME: 100 to .01 seconds.

MONITOR OUTPUT: Positive linear sawtooth, 45 volts peak; Blanking out, 75 volts negative.

EXTERNAL SWEEP: 200 volts gives full sweep width.

AMPLITUDE MODULATION

INTERNAL SQUARE WAVE: RF output alternately 0 and unmodulated CW value. Frequency 800 to 1200 cps.

EXTERNAL: 30 volts maximum signal increases RF output from 0 to maximum.

POWER INPUT: 105 to 125 volts; 60 cps.

Write us for complete details of these new oscillators. We'll also send you our new short form catalog, which describes Alfred's complete line of packaged traveling wave tube amplifiers.

ALFRED ELECTRONICS

897 COMMERCIAL STREET
PALO ALTO, CALIFORNIA

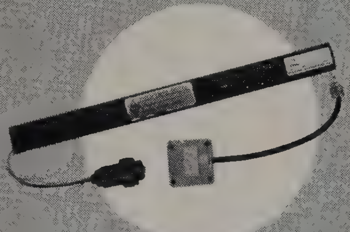
3A

Circle Reader Service Card 46

forward
look
in
backward
waves

You can look forward to an exceptionally long service from any backward wave oscillator that bears the Stewart label. One important reason is that Stewart Engineering pioneered the first commercial BWO, and is today the only manufacturer specializing solely in high-performance backward wave tubes.

Guaranteed for a minimum life expectancy of 500 hours, Stewart BWOs characteristically last much longer. Their cost, spread over their life span, usually averages less than a dollar an hour.



Type OD 10-15 backward wave oscillator. Power output 10-20 mw over 10-15.5 kmc frequency range.

We've reserved a copy of our new brochure for you, plus specifications on BWOs covering the range from 1 to 18 kmc. We'll also be happy to supply details on custom-engineering tubes with special frequency, power output, voltage, and current specifications. Write today.

STEWART
ENGINEERING
CORPORATION

SANTA CRUZ • CALIF.

New Products

(Continued from page 86)

The SRL Series O. D. precision waveguide gages are designed for the needs of Microwave Design Engineers and Calibration, Incoming-Inspection, Standards, and Quality-Assurance (Control) personnel for an accurate and rapid GO, NO-GO means of checking the critical outside dimensions of the standard waveguide transmission lines used in UHF, SHF, and EHF instruments and systems. The range of waveguides covered is from WR 975 (0.75 - 1.12 kMc) to WR 15 (75-110 kMc).

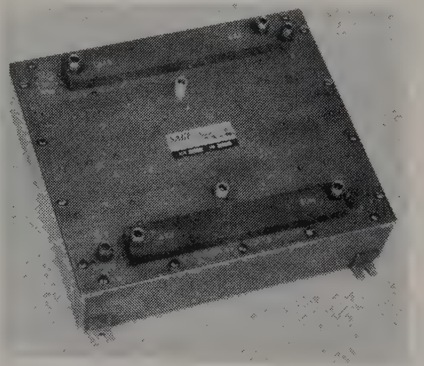
Twenty-two gages, one for each size, are used. Every gage is precision-ground from tool steel to a tolerance of 0.0002 inch, and is treated to insure long wear and freedom from corrosion. Edges are beveled to protect the microwave components under inspection. Each gage is stamped with the waveguide "WR" designation as an aid to rapid selection for gaging per MIL and EIA standards.

Minimum dependence on the skill of the user is needed to gage waveguide using a Series I. D. or Series O. D. Gage since its design is based on a GO, NO-GO configuration. Four dimensions of the gage are chosen to correspond to the high and low limits of the width and height of the waveguide. An acceptable waveguide can only be inserted between the low-limit portions of the Series O. D. Gage which is of the popular "snap-gage" design. The outer dimensions of any length of waveguide can be gaged as well as bends and twists.

Circle Reader Service Card 104

—mwj—

SAGE LABS ANNOUNCES COAXIAL MONOPULSE ANTENNA FEED ASSEMBLY



Sage Laboratories, Natick, Mass., announces the development of the Model SS750C, an integrated Coaxial Monopulse Antenna Feed Assembly offering performance exceeding that obtained with conventional rat-race or hybrid ring configuration. The unit is suitable for use with a quad helix or similar type antenna array.

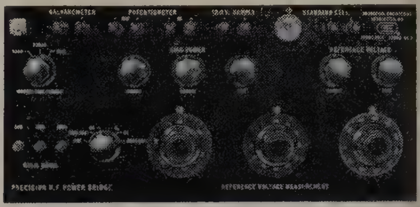
The operating frequency range of the Model SS750C is 215-260 Mc, but may be extended to 190-290 Mc with some sacrifice in performance. Within the 215-260 Mc range, boresight nulls for azimuth and elevation are 30 db minimum. Antenna output coupling amplitude is ± or — .1 db; phase is ± or — 5° maximum. VSWR for all ports is 1.2 maximum. Models for other frequency bands are available on request. All connectors are female Type "N".

The unit weighs 13 lbs. with overall dimensions of 4 7/8 inches x 11 5/8 inches x 14 inches.

Circle Reader Service Card 105

—mwj—

RF POWER BRIDGE SUPPLIED TO AIR FORCE



One-fourth percent accuracy of substituted dc power (above 500 microwatts) is reported with the Precision R.F. Power Bridge, model PB-1, manufactured by Weinschel Engineering, Kensington, Md.

The instrument is currently being supplied to the Air Materiel Command in conjunction with the Air Force Calibration Program.

The PB-1 is designed for use with 200 ohm bolometer mounts using either 4.5 or 8.75 ma barretters or a pair of 13 ma thermistors. An accuracy of 1/4% in substituted power is readily achieved between 500 microwatts and 20 milliwatts.

Circle Reader Service Card 106

—mwj—

RESISTANCE CARDS FEATURE MICROWAVE ATTENUATOR MATERIAL

A metal film resistance card, manufactured by the Filmohm Corp., New York, N. Y., is a new microwave attenuator material. The base is a fine weave glass cloth impregnated with high temperature thermosetting resin which meets MIL-P-18177. Resistance material is a thin film of pure metals, approximately 50 millionths of an inch thick, uniformly deposited on one surface of the plastic. A protective coating is provided over the metal film.

The combination of a metal resistance film, deposited on a laminated fibre glass plastic base which is dimensionally stable, has extremely low moisture absorption. No special machining techniques are required. The resistance cards can be punched, drilled, sheared, machined, and sanded with normal care to avoid scratching the film surface.

Standard resistance cards are 5 x 12 inches, and .025, .032 or .062 thick. Resistivity range is 25 to 750 ohms per

(Continued on page 90)

EMPIRE'S Model NF-112

NOISE and FIELD INTENSITY METER 1-10 KMC

One Meter One Antenna

The Empire Devices Model NF-112 is a compact, self-contained noise and field intensity meter...with built-in power supply. Using a single log periodic pick-up antenna...and an impulse generator...it enables you to measure, quickly and reliably, field intensity and RF interference over the entire frequency range from 1-10 KMC.

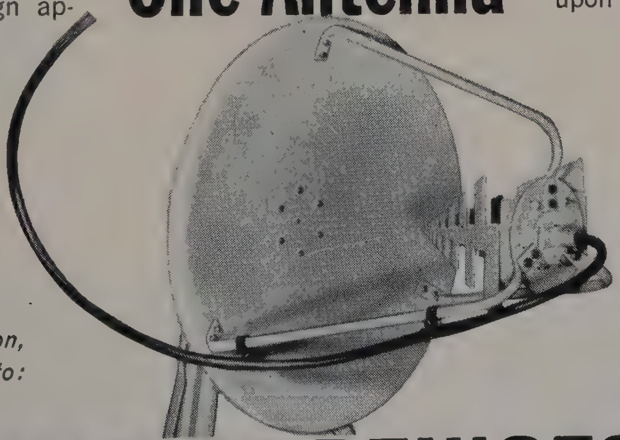
The design, reliability, accuracy, construction and calibration techniques employed in the NF-112 have been successfully proven through many years of field and laboratory use in the low frequency companion instruments, NF-105 and NF-205.

Compactness has been achieved by housing the basic components (common to all frequency ranges) in a single unit, and the necessary RF circuits in four speedily interchangeable, plug-in tuning units... avoiding costly repetition of circuitry and components. This design approach, together with the use of an impulse generator as calibrator, has greatly reduced the instrument's size, weight, complexity and ...best of all...**lowered the cost considerably.**

Model NF-112 measures only 19½" x 18½" x 21½" and, including a tuning unit, weighs 130 lbs. Complete shielding and filtering, plus well-tracked tuned circuits achieve excellent spurious response rejection. A wide band - narrow band switch permits optimum sensitivity for broad band (pulsed signals) and narrow band (CW) reception (AFC, of course). Average and peak reading VTVM (slideback, too).

For measurements in accordance with Specifications MIL-I-6181 C&D, MIL-I-11748-B, MIL-I-26600 and MIL-STD-449.

Plan to attend our next seminar on interference instrumentation, details upon request.



For further technical information, send for Catalog 604 to:

ed EMPIRE DEVICES, Inc.
AMSTERDAM, NEW YORK • VICTOR 2-8400

MANUFACTURERS OF: FIELD INTENSITY METERS • POWER DENSITY METERS • IMPULSE GENERATORS • COAXIAL ATTENUATORS • CRYSTAL MIXERS

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To awaken a
sleeping giant

the newest communications assignment at Amherst Laboratories

In the event of attack...an electronic klaxon will interrupt the lonely vigil of tomorrow's retaliatory force. The Air Force's Minuteman will erupt from underground silos and streak toward enemy targets...at a moment's notice. The fire command will originate from a remotely located control-launch center and be carried by a jam-resistant signal.

New techniques in Electronic Communications must be developed and converted to practicality. This is just one of the many advanced Ground, Air and Space Communications assignments at Amherst Laboratories.

PROFESSIONAL STAFF AND MANAGEMENT OPPORTUNITIES *are unlimited for Physicists, Mathematicians and Electronics Engineers with advanced degrees and creative desire.*

You are invited to direct inquiries in confidence to Mr. Daine C. Maxwell, Amherst Laboratories...or call NF 3-8315 for information. All inquiries will be acknowledged promptly.

SYLVANIA ELECTRONIC SYSTEMS
A Division of SYLVANIA
Subsidiary of GENERAL TELEPHONE & ELECTRONICS
1182 Wehrle Drive, Williamsville, New York

AMHERST LABORATORIES

Shrinking the Universe . . . through Communications

New Products

(Continued from page 88)

square. Standard values from stock include 50, 100, 125, 150, 180, 200, 300, 377, 400, and 500 ohms per square.

Circle Reader Service Card 107

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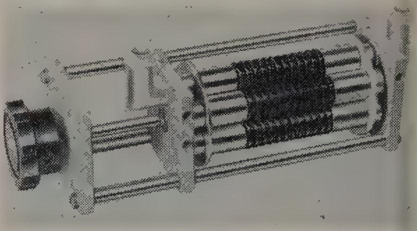
ATTENUATORS BASED ON PULL-TURN-PUSH PRINCIPLE



Microlab, Livingston, N. J., has announced a line of precision coaxial turret attenuators for use up to 10,000 mc, known as the AS series.

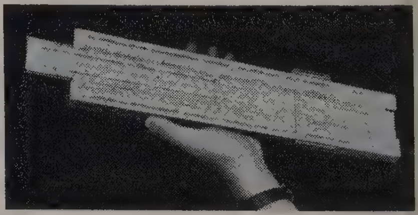
Based on the Pull-Turn-Push principle, these units provide a choice of any six values of attenuation from zero to 20 db. Over the frequency range of 4 to 10 kMc they provide an accuracy of ±0.5 db and a maximum VSWR of 1.4. They have an average power rating of 2 watts and a peak rating of 2 kw. Provision is made for either panel or chassis mounting.

The attenuators are available from stock in a wide variety of attenuation values and are priced at $280 each. They are normally supplied with type N female connectors but types BNC, TNC, C, and HN are also available.

Circle Reader Service Card 108

—*mwj*—

RADIATION SLIDE RULE PERMITS ONE STEP CALCULATIONS



A reduction in the number of steps formerly required to obtain information relating to the radiation from a black body is made possible by a newly designed slide rule available from Walsh Engineering Sales Company, Inglewood, Cal.

The slide rule, manufactured by A. G. Thornton Ltd., England, in many instances provides information with one setting of the slide and/or cusor. Direct reading of values in both watts and photons per square centimeter are possible in every case. Twin temperature scales provide readings in degrees centigrade or degrees absolute over a range of —180°C to 10,000°C. Quantities such as the radiant

(Continued on page 98)

P-BAND

LECTRONICALLY SWEPT SIGNAL SOURCE

MODEL 630-P

• FREQUENCY	400 - 1200 mcs
• OSCILLATOR	EIMAC X - 747
• SWEEP RATE	C.W. & 0.1-100 cps
• A.M. MODULATION	800-1200 CPS SQUARE WAVE
• SWEEP OUTPUT	LINEAR SAWTOOTH
• PRICE	$2850.00
• DELIVERY	4 - 6 WEEKS

Another new electronically swept Signal Source oins our family.

The addition of the model 630-P extends the overage one octave lower than before. The im-ressive frequency coverage of Wave Particle weepers now extends from 400 MC to 70 GC in xteen models.

The 630-P looks just like the other models and ghtfully so. It contains similar electrical specifiations to the others while providing a frequency overage of one and one-half octaves in P band. eart of the 630-P is the newly announced Eimac -747, a highly compact permanent magnet ocused, voltage tunable magnetron. The X-747 lus Wave Particle experience and engineering add p to produce a P Band Sweeper to meet your eeds.

If your needs also include Wave Tube Amplifiers nd auxiliary equipment such as Microwave Levelers lease contact us.

OR ADDITIONAL TECHNICAL INFORMA-ION AND A DEMONSTRATION CON-ACT YOUR NEAREST REPRESENTATIVE OR WRITE DIRECTLY

Wave Particle Electronic Sweep Signal Sources

	freq. (GCS)		freq. (GCS)
630-P	0.40-12	640-X	8.0-11.0
630-L	0.98- 2.1	610-XKU	8.0-16.0
630-S	2.0- 4.0	620-KU	12.4-18.0
620-C	4.0- 8.0	610-K	18.0-27.0
630-CX	4.8- 9.6	611-K	15.5-24.0
620-X	7.5-11.0	600-KA	26.5-41.0
630-X	82-12.4	610-KA	27.0-40.0
631-X	7.0-11.0	600-V	63.0-75.0

wave particle

3221 FLORIDA AVENUE RICHMOND, CALIFORNIA

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LAND-C-AIR SALES CO. • 72 MAIN STREET, TUCKAHOE, NEW YORK • Woodbine 1-4700
MICHAEL S. COLDWELL, INC. • 41 LANCASTER ROAD, NEEDHAM 92, MASS. • Hillcrest 4-1142

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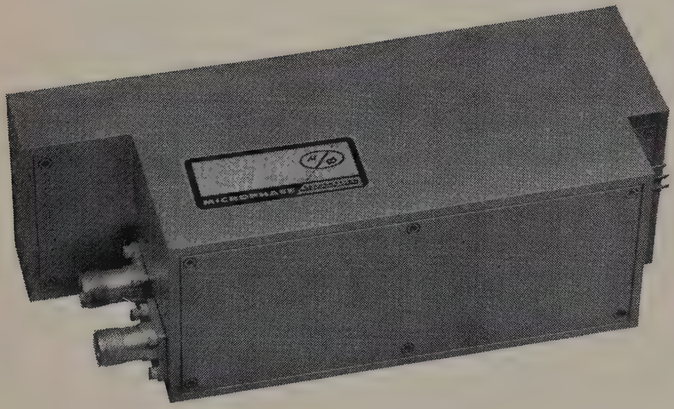
ALL-SOLID-STATE

MC Receivers



MICROPHASE PART NUMBER SF21718-2

The MICROPHASE SF21718-2 Receiver Head combines preselector, mixer, local oscillator, IF preamplifier and voltage regulator into one compact, integrated package. MICROPHASE Front Ends are well suited for high-reliability systems which demand optimum size and weight and minimum power consumption.

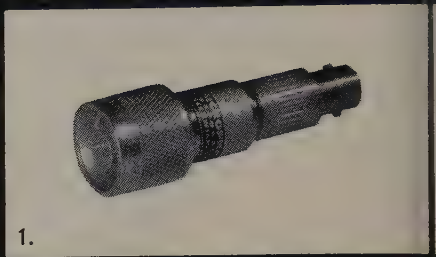
Since the various components of MICROPHASE packages are custom-tailored to work together, they provide efficient and trouble-free performance for critical applications.

Packages in different frequency ranges, with a variety of IF outputs, are also available from MICROPHASE.

SPECIFICATIONS

Preselector Tunable Range	**1700-1850 mc**
Local Oscillator	**Crystal-Controlled**
Overall Noise Figure	**12 db**
RF/IF Signal Gain	**25 db**
IF (30 mc) Bandwidth	**4 mc**
Image Rejection	**50 db**
RF and IF Impedances	**50 Ohms**
Power Requirement	**28 vdc @ 60 ma**
Overall Size	**50 cu. in.**

OTHER MICROPHASE COMPONENTS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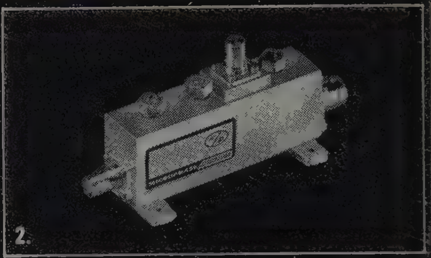
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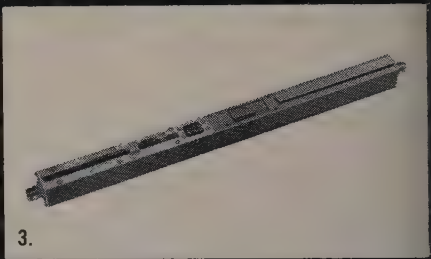

3.

1. **Detector Mount Model CCV3112**—covers the 100 to-12,000 mc frequency band and has an averag tangential sensitivity of —45 dbm. This mou can be provided with Type N or TNC input conne tors and TNC or BNC output connectors. The overa length is 2¼ inches, with or without DC return.
2. **Preselector/Mixer Model CIP21619**—operates ove a signal-input band of 1600-1900 mc with over 4 db rejection of image frequency. The noise figur is 8 db max (with 2.0 db IF), and signal-to-LO isola tion is greater than 30 db. The noise figure is mair tained within 1 db over a temperature range c −30° to +80° C.
3. **S-Band Bandpass Filter Model CFS22223B1**—ha 0.5 ±0.2 db insertion loss throughout its pas band of 2200-2300 mc. Attenuation of 60 db, 10 from both cutoff frequencies, maintained from D to 20 kmc. Unit has integral double-slug tuner t adjust match to better than 1.03 VSWR at any fr quency in the passband.

MICROPHASE CORPORATION

Box 1166W Greenwich, Conn. NO 1-6200 WE 9-9190 TWX GNWICH CONN 75

Circle Reader Service Card 50

ANDREW CORPORATION

Chicago Illinois

The mere fact that Andrew Corporation is 24 years old tells a story.

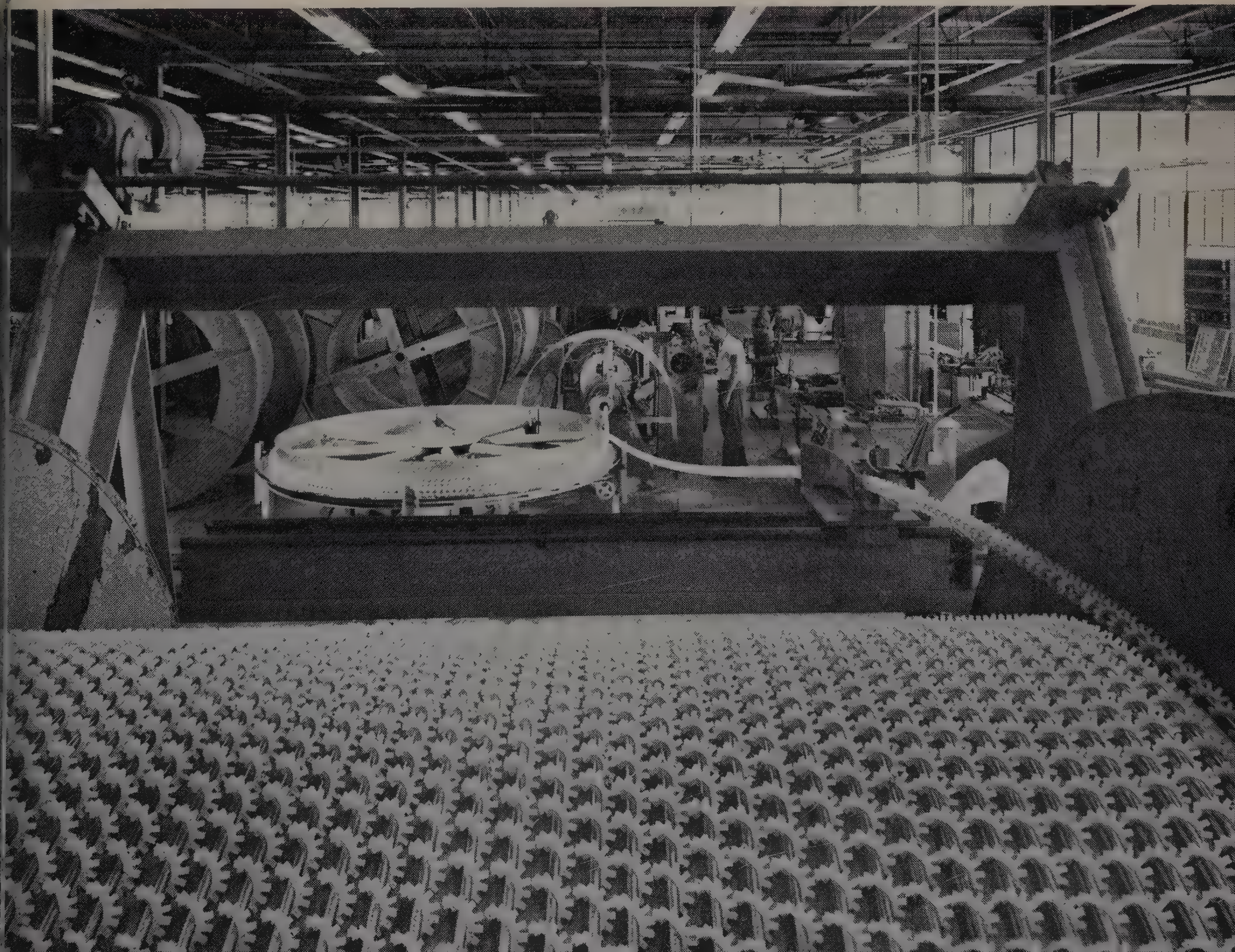
It tells that the firm, grown to $8,000,000 in sales, specializing in the general field of antenna systems, started in the mid-thirties — a period when it took courage to launch a new company.

Dr. and Mrs. Victor J. Andrew provided the necessary courage as they set up operations in a small basement workshop on Chicago's south side. With the part-time help of a school boy, Dr. Andrew, a University of Chicago PhD, launched the company destined to become a leader in its field.

Broadcasting was the first market served by Andrew. Knowing that the broadcaster's attention was focused on increased coverage, Dr. Andrew concentrated his talent on filling this need by providing consulting engineering services. Though the products and services offered by the company have changed over the years this basic orientation toward solution of the customer's total problem remains.

As the firm gained acceptance Dr. Andrew was called upon to design directional antenna systems and began to manufacture transmitting specialty items such as tuning and phasing equipment and coaxial cables. System per-

Heliax cable production in Orland Park plant.



Heavy duty 28-foot Hubloc reflector.

formance, not hardware, was the reason for early success. In those days it was not unusual to see Dr. Andrew personally scaling a high tower to inspect or repair equipment.

Still very much part of Andrew, Dr. Andrew as Chairman of the Board and Mrs. Andrew as President, concentrate their active participation on financial guidance, long range planning and marketing studies in foreign areas. Dr. Andrew is a Fellow of the IRE.

In 1940, C. Russell Cox (BE, MS, and MBA, University of Chicago) joined the growing firm. He helped guide Andrew through rapid expansion during and after World War II. Since 1950, as Vice-President and General Manager, he has actively directed the operation of the company. In addition, Mr. Cox is a Director of the Electronic Industries Association and Chairman of it Industrial Electronics Division.

Andrew today employs about 350 people while it California and Canadian affiliates employ about 40 persons each. Net sales for 1960 will reach approximatel 8 million. The company and its affiliates are still wholl owned by the Andrew family. The affiliates include: Andrew Antenna Corp., Ltd., Whitby, Ontario, Canada; Andrew California Corp., Claremont, Cal.; Andrew International Corp., Chicago, Ill.

John S. Brown (BSEE, Purdue University, MS, Northwestern University) is Director of Engineering. H joined Andrew in 1942 and is a past chairman of th Chicago Section of the IRE. Under his direction, Andrew developed two-way radio base station antennas, rig transmission lines, and antennas for FM and TV, an microwave antennas for STL use in the late '40s. A expanded Engineering Department continues to develop new products for ever higher frequency ranges. The Engineering Department is currently comprised of sixty people and is divided into three sections:

Dr. R. F. H. Yang (BS, National Wu Han University MS, PhD, University of Illinois) heads the Antenna Design Group. He holds numerous patents on antenna developments and is a specialist in the theoretical analysis of complex antenna systems.

Ernest H. Johnson (BSEE, Illinois Institute of Technology) supervises the transmission line group and is responsible for coaxial and waveguide development as well as high power RF switches and filters.

Harry Hirst (BSME, Illinois Institute of Technology) is Chief of the Mechanical Design Group and has overall responsibility for the mechanical design and prototype construction of all products.

One of every five employees is engaged in active engineering work while one of every ten employees is a graduate engineer. Although there are many firms with larger manufacturing facilities and others with larger engineering departments there are few if any companies with a significant combination of both exclusively devoted to the design and production of antenna system equipment. Thus, while neither old nor large in the general business sense, Andrew, as a twenty four year veteran in the young electronics industry is a dominant force in its selected sphere of specialization.

Engineering-Manufacturing-Marketing unity enables

Main Andrew plant at Orland Park, Illinois.

ndrew Corporation officers, left to right, Dr. Victor J. Andrew, Chairman of the Board; Aileen S. Andrew, President; and C. Russell ox, Vice-President and General Manager.

ndrew to offer and deliver total solutions rather than iece parts for complex antenna system requirements.

ACILITIES AND PRODUCTS

Situated on a 430 acre tract especially selected for eedom from electrical disturbances, a newly completed lant and office building provides 124,100 square feet f clean, modern, well lighted, and extensively equipped ıanufacturing space; a 10,000 square foot engineering boratory; and 24,000 feet of general office space. Total oor space including affiliates is 186,000 square feet. A ding on the Wabash Railroad affords efficient handling f bulk shipments.

Extensive instrumentation with multiple sets of equipıent for popular frequency ranges and ready access to x noise free antenna test ranges enabled Andrew to rovide the industry's first antennas with guaranteed elecical characteristics.

Andrew carries over 60 microwave antennas covering ll assigned frequencies. Sizes range from two feet in iameter upward. Plane and dual polarized units are ocked. In addition, Andrew California Corporation ıanufactures and stocks microwave waveguides and acssories. Andrew also designs and produces microwave ntennas for many critical military systems.

Fixed Station Antennas: Scores of omni-directional nd directional communications antennas, cables and acessories are carried in stock for same day shipment.

Telemetry Antennas are designed and produced at ndrew California Corporation for missile tracking and lated applications. A special broadband stainless steel ıbmersible antenna of Andrew California Corporation esign was used in the recent successful Polaris missile unching.

FM Broadcast Antennas: The Andrew Multi-V is used more than half the 900 FM stations currently in operaon. It has become a standard of the industry.

Hubloc Antennas: Hubloc, a patented structural connection, is a newcomer to the product line and shows great promise. A new structural joint, comprised of an embossed tube end which provides a press fit in a precision formed keyway, Hubloc delivers up to 50 per cent more strength than welded or bolted joints of equal tube size. This development is principally employed in large diameter reflectors.

Heliax Cable: The construction, featuring a continuously corrugated outer conductor, permits minimum wall thickness and easy forming, yet provides great resistance to crushing. Kink proof and crush proof, Heliax is used in most applications where permanence, ease of installation, and high electrical quality are required.

Coaxial lines up to 14 inches in diameter and waveguides up to WR2300 are in current production. Beginning with the early DEW Line installations Andrew coax and waveguide were employed in most high power radar and communication complexes.

SALES AND MARKETING

Sales work is performed by employees rather than distributors or agents. Most sales personnel are graduate engineers. In addition to sales offices at the plant locations, Regional Offices are maintained in the New York, Boston, and Washington, D.C. areas.

Robert P. Lamons (BSEE, Illinois Institute of Technology) is Director of Sales and Marketing and Vice-President of Andrew California Corp. He joined in 1945. Mr. Lamons is a registered professional engineer.

C. Robert Lane (BSEE, University of California, MBA, Boston University) is Sales Manager and directs field sales engineering, and sales administration. He has been with the company 6 years.

Robert C. Bickel (BSEE, Illinois Institute of Technology, MBA, University of Chicago) is Marketing Man-

(Continued on page 96)

7.5db
Noise Figure

in
C or X BAND

LEL
LOW NOISE
MIXER-PREAMPLIFIER
MODEL MMX-6
FREQ. RANGE
5.5-6.6 KMC
INT. FREQ.
30 MC
J1 POWER
J2 I.F.
V1 417A
V2 417A

MATCHED MIXER-PREAMPLIFIERS

(Coaxial units available for L, S and C bands)

TYPICAL SPECIFICATIONS

Noise Figure	6.5db typical 7.5db maximum
Bandwidth	8mc
Inputs	RG52/U Waveguide
Minimum Overall Power Gain	25db
LO Power Requirement	1mw typical

For complete specifications and catalog write:

LEL INC.
Akron Street
Copiague, L. I., N. Y.
AMityville 4-2200

Circle Reader Service Card 51

ANDREW

(Continued from page 95)

ager and administers the marketing research, produc planning, and advertising activities. He joined in 1946.

EMPLOYEE BENEFITS

An extensive employee benefit program is underway This program includes annual bonuses, profit sharing payment of full tuition for employee education, and major medical insurance.

A benefit is provided to Andrew employees through the Aileen S. Andrew Foundation Scholarship Fund which awards a scholarship of up to $4,000 to any child of any employee who attends an accredited four year college program.

In addition, the foundation grants fellowships to outstanding foreign students for engineering study in the United States. A scholarship is also given to the leading graduate of the local Orland Park High School.

GROWTH

Andrew has grown with the industry. Recently, volume has increased by 20 per cent per year and is expected to double again within the next 5 years. Growth is planned and orderly, permitting acceptance and production of large contracts without outside financing or progress payments. These management techniques have led to financial stability. Growth is financed from current profits.

Andrew looks to the challenge of the future with anticipation and confidence.

ALL SIZES
M S FLANGES
IN STOCK

THE FINEST QUALITY BRASS AN ALUMINUM STANDARD WAVE-GUIDE FLANGES in stock at Formcraft—all precision made to military standards. For rigid and flexible waveguides.

Special flanges to your specifications. Send sketch or blueprint for a quotation.

SEND FOR NEW BROCHURE #14B
DESCRIBING AND ILLUSTRATING ALL THE STOCK FLANGE

Formcraft TOOL C
2465 S. Archer Ave. • Chicago 16, Ill. • CAlumet 5-317
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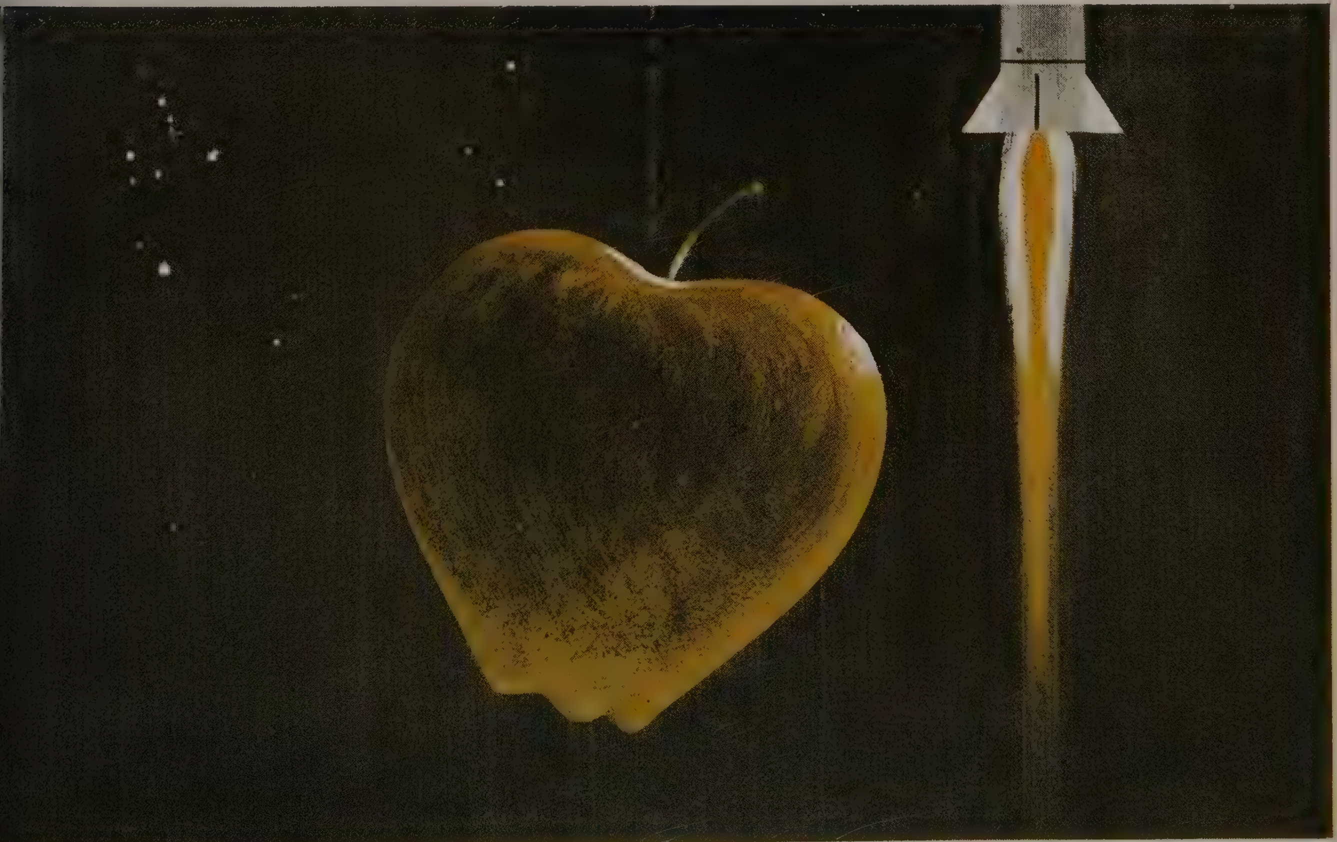
BUT, SIR ISAAC, WE'RE NOT GUIDING APPLES!

Until a ballistic missile is in free fall, our inertial guidance systems must be able to account for both rocket thrust and gravity. Making them this smart is a tough job, but we hit the mark so well on Thor that all of this country's long range missiles will soon be guided inertially. If you would like to help us keep pioneering new guidance systems, and have a BS, MS or PhD in Physics or Math, or an ME or EE, please contact Mr. B. I. Allen, Director of Scientific and Professional Employment, 7929 S. Howell Ave., Milwaukee 1, Wisconsin. AC SPARK PLUG THE ELECTRONICS DIVISION OF GENERAL MOTORS

AC



New Products

(Continued from page 90)

flux density in a given wavelength or the corresponding quantities expressed in photon units can be obtained readily for a black body over a range $\lambda T = 2 \times 10^2$ to $\lambda T = 4 \times 10^6$ micron degrees with an accuracy of about 1 per cent.

The "F5100" Radiation Slide Rule has 7 scales on the stock and 6 scales on each face of the reversible slide. Of laminated Mahogany construction, celluloid faced and incorporating springs, the large slide measures 19 ¼ inches by 3 ¾ inches, and is supplied with case and instruction manual and priced at $41.00.

Circle Reader Service Card 109

—*mwj*—

FIVE INCH BROADBAND ISOLATOR OFFERED BY E&M LABORATORIES

A five inch broadband isolator, Model X11OLI, is available from E & M Laboratories, Van Nuys, Cal. It provides a minimum isolation of 30 db with a maximum VSWR of 1.10 and a maximum insertion loss of 1.0 db over the entire X-Band frequency range, from 8.2 - 12.4 kMc.

This isolator is available for $175 and quantity orders will be quoted on request.

Circle Reader Service Card 110

—*mwj*—

POWER METER USED IN LABORATORY, FACTORY, FIELD

AVERAGE POWER METER MODEL 31A1
Microline

Sperry Microwave Electronics Co., Clearwater, Fla., has announced the Sperry Microline Model 31A1 Average Power Meter, designed specifically for laboratory, factory or field use when precision measurements of power are necessary, and accurate to 3 per cent of full scale reading.

It can be used to measure pulsed or cw power of radar, radio, television, microwave and microwave relay equipment components. The frequency coverage is limited only by the characteristics of the bolometer and mount used. Model 31A1 measures power levels up to 10 mw directly; this range can be extended as required by using directional couplers and/or calibrated attenuators.

Circle Reader Service Card 111

—*mwj*—

IMPROVED CERAMIC-METAL THYRATRON DESIGNED FOR QUICK, EASY MOUNTING

Designed by Edgerton, Germeshausen & Grier, Inc., Boston, Mass., to provide radar modulator package designers with greater versatility and convenience as well as improved electrical performance, the new 7621/HY-2 Hydrogen Thyratron is equipped with a cathode flange for quick, easy mounting and through-hole tabs to which filament and grid connections are easily made. Flexible wire leads and separate mounting sockets are no longer necessary.

In spite of its small size, the Thyratron is capable of switching 350 kw peak power with only a 30 second filament warm-up time. Operation at 125° ambient temperature is possible without forced cooling when the tube is operated at its maximum plate dissipation factor (P_b) of 2.7×10^9.

EGG
7621/HY-2

A hydrogen reservoir, connected internally across the cathode filament, increases tube life.

Rugged construction enables the 7621/HY-2 to withstand shocks of 200 g at 11 ms duration and vibration from 0-2000 cps at 20 g. These tubes may be used as replacements for or in new applications specifying conventional 1258, 3C45 or 4C35 glass envelope tubes with considerable savings in weight and size for airborne and shipboard applications as well as ground-based equipment.

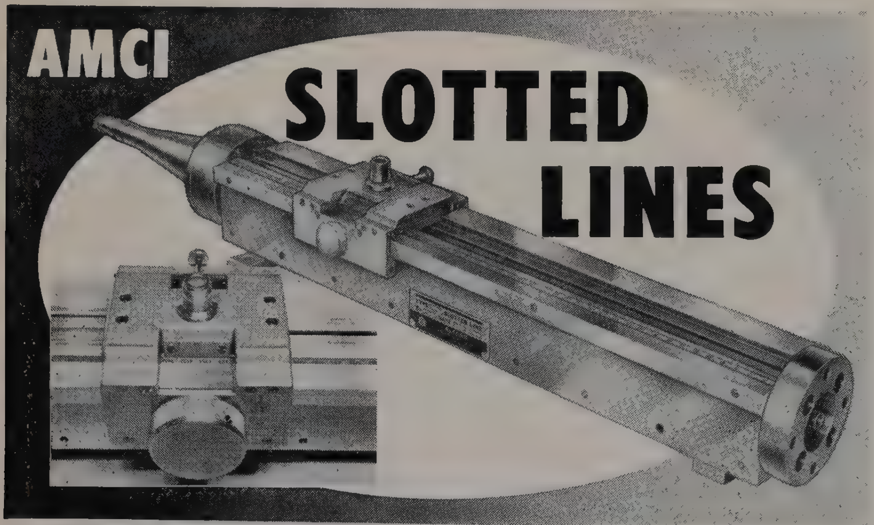
Circle Reader Service Card 112

—*mwj*—

X-BAND VTM DEVELOPED BY GENERAL ELECTRIC

An X-band voltage-tunable magnetron, developed by the Power Tube Department of General Electric Co., Schenectady, N. Y., has a minimum CW power output of 1 milliwatt over the 8500 to 11,000 Mc frequency range.

Designed as a complete, packaged RF power source, the new VTM, type Z-5429, can be used as a driver or local oscillator tube in space telemetry, electronic counter-


AMCI
SLOTTED LINES

FEATURES

- ***Rated residual SWR*** — under 1.010; rated error in detected signal — under 1.005.
- ***Several models*** covering various bands from 50 to 4000 mc.
- ***Engraved scales and verniers*** permit one to read the probe position to 0.01 centimeters.
- ***Optional accessory:*** a rack and pinion carriage drive than can be engaged or disengaged at will.
- ***Precision tapered reducers*** are available for use in making accurate measurements in a wide range of rigid and flexible coaxial transmission lines.

Write for complete information on AMCI Slotted Lines.

AMCI
ANTENNA SYSTEMS — COMPONENTS · AIR NAVIGATION AIDS — INSTRUMENTS
ALFORD *Manufacturing Company*
299 ATLANTIC AVE., BOSTON, MASS.

Circle Reader Service Card 53

measures, rapidly tuned radar, doppler radar, and similar applications.

Like the other tubes in General Electric's family of VTM's, the Z-5429 has linear tuning, rapid tuning, flat power output, high efficiency, rugged metal-ceramic construction, small size, and light weight.

The tube can be tuned over all or a part of its operating frequency, and also can be used at a fixed frequency.

In typical operation, anode voltage is 1250 volts at 9000 Mc; anode current is 10 to 20 ma; filament voltage is 2.5 volts and filament current is 3 amperes. Tuning rate is 9 Mc per volt.

The tube operates at a maximum voltage of 2000 volts, maximum anode current of 30 ma, and maximum filament current of 3.2 amperes.

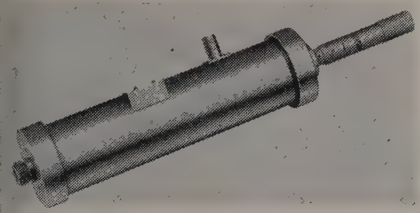
Circle Reader Service Card 113

—mwj—

NEW LABORATORY STANDARD VOLTMETER FOR 10 MC TO 1000 MC

A new laboratory standard voltmeter for the measurement of voltages or the calibration of ac voltmeters operating in the range of 10 Mc to 1000 Mc at voltages of 0.5 volt to 300 volts is announced by Ballantine Laboratories Inc., Boonton, N. J. The Model 390 NBS A-T Voltmeter features a stability of less than one per cent deviation from National Bureau of Standards calibration for at least one year.

The Model 390, based upon designs of the National Bureau of Standards, consists of an adjustable waveguide below-cutoff attenuator feeding a UHF vacuum thermocouple. The DC output from the thermocouple is measured on an external millivoltmeter. The unknown signal is connected to the input electrode, and the micrometer setting is adjusted to produce a standard reading on the millivoltmeter.



The voltage is then obtained from the calibration chart which shows the input voltage for all settings of the micrometer at the frequency of measurement.

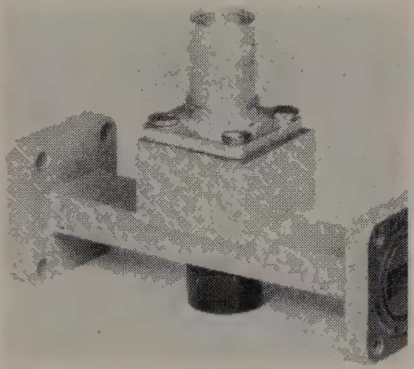
The barrel of the variable waveguide-below-cutoff attenuator is machined from a special casting, then plated and lapped to a final finish. The movable electrode and thermocouple are mounted on a machined carriage that slides inside the attenuator barrel on six nylon pins and two sets of plated finger stock. They are driven by a two-inch micrometer, calibrated in ten-thousandths of an inch.

The micrometer is coupled to the carriage assembly by means of a spring and ball-bearing arrangement. The thermocouple is an insulated, ultra-high-frequency type. After assembly, each NBS A-T Voltmeter is heat-cycled for one month to remove any mechanical stresses. After manufacture, each Model 390 NBS A-T Voltmeter must be calibrated by the National Bureau of Standards, Boulder, Col.

Circle Reader Service Card 114

—mwj—

BENDIX ANNOUNCES SINGLE DIODE SWITCH



The Bendix Corp., York, Pa., has announced a Single Diode Switch for K-band applications. This silicon device is capable of switching greater power than 0.2 watts at speeds of several millimicroseconds. Total modulation voltage needed is 1.0 volts peak. The on-off ratio is 20 db with an insertion loss of 2 db.

Although the device shown has been designed for K-band, other bands are available with very little change in specifications except size. (2 ½ inches x 1 ¾ inches x ⅞ inch for K-band unit.)

If a greater on-off ratio is required, these units can be cascaded in series. A dual unit is available with the same dimensions which had an on-off ratio of 40 db with an insertion loss of only 4 db.

The use of a silicon junction device allows the use of this equipment under environmental conditions usually associated with silicon semiconductors. So far it has been used in transmitters and test equipment.

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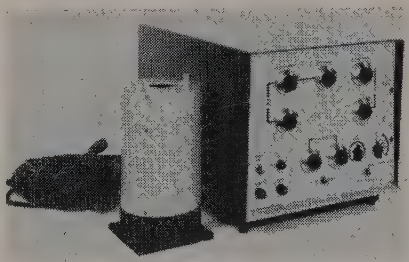
—mwj—

E. G. & G. TRACE PLOTTER INCREASES TW SCOPE SENSIBILITY FIFTEEN TIMES



A TW oscilloscope Trace Plotter has been developed by Edgerton, Germeshausen & Grier, Inc., Boston, Mass. Known as the EG&G Model 860 Trace Plotter, it detects, amplifies and plots trace deflec-

(Continued on page 102)

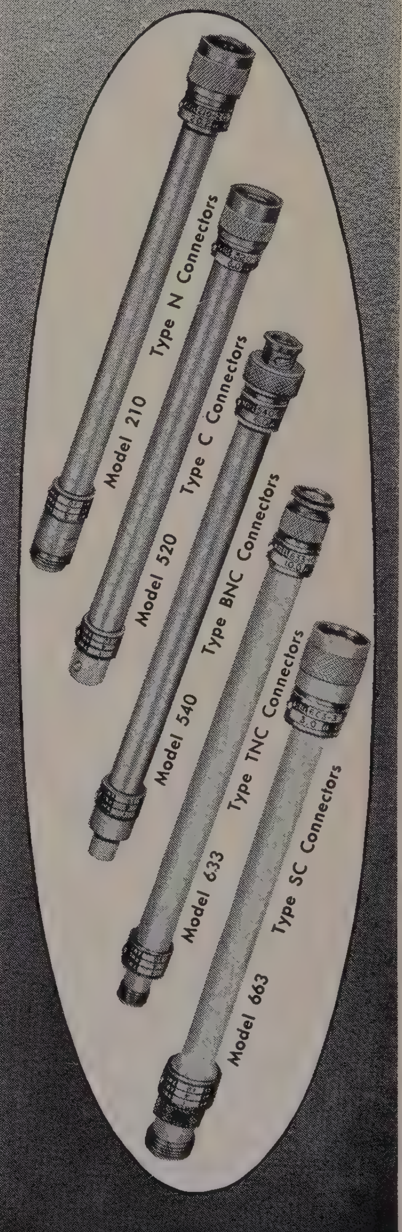
WEINSCHEL

FIXED COAXIAL ATTENUATORS

1 to 12.4 KMC

50 Ohms 1 to 20 db

Connectors: Type N, C, BNC, TNC or SC. Each type with male/female, double male or double female connectors. Made with Weinschel Film Resistors for maximum stability.



® WE CO

Write for complete catalog, specifying frequency range of interest.

Weinschel Engineering

KENSINGTON, MARYLAND

Circle Reader Service Card 54

Table for Determining

CUTOFF WAVELENGTHS FOR CIRCULAR GUIDES

By WILLIAM HESTER

The accompanying table gives the cutoff wavelengths for the first forty modes in circular waveguide. The cutoff wavelength is given by the equation:

$$\lambda c = \frac{2\pi a}{\mu}$$

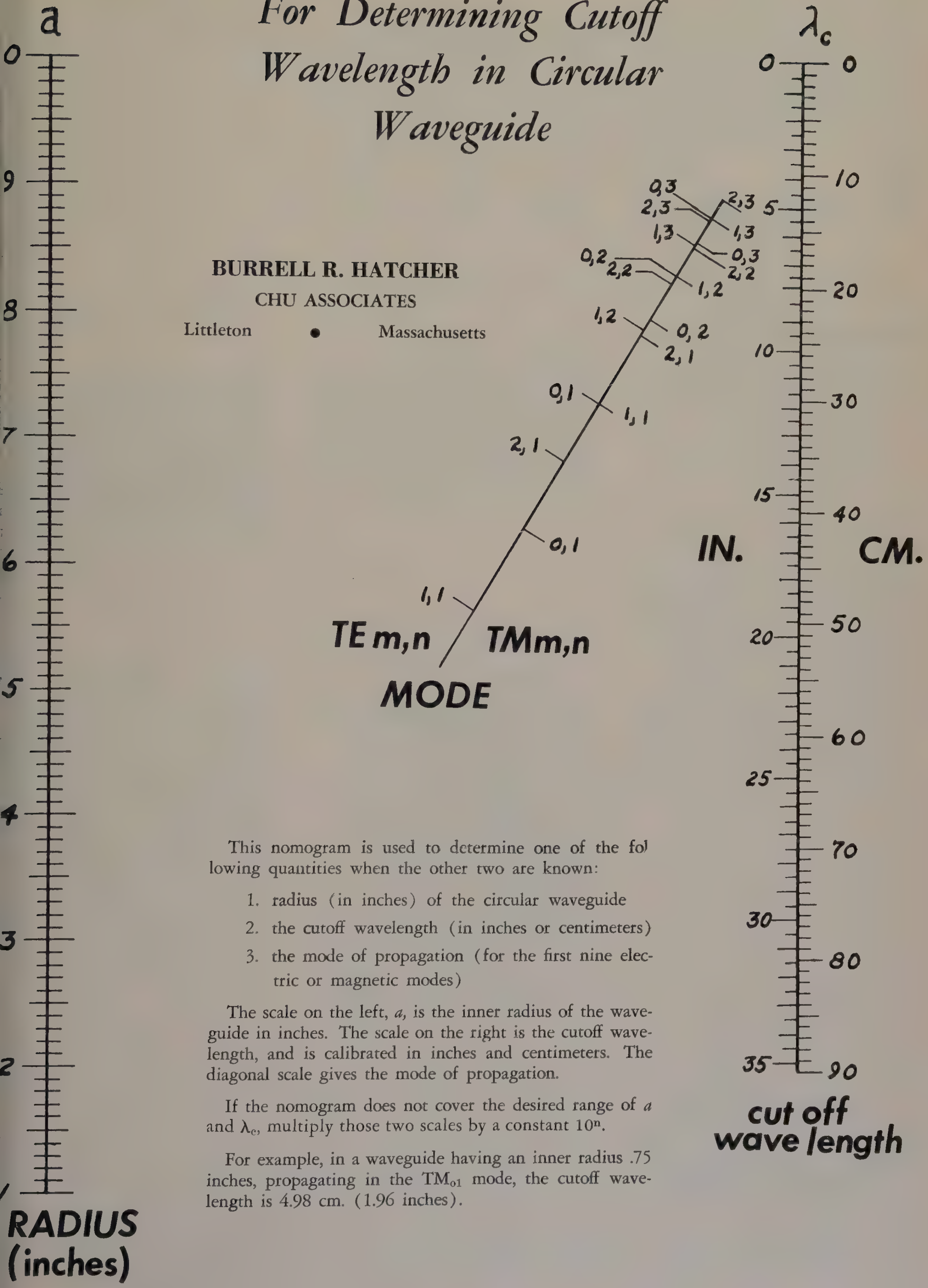
where a is the radius of the waveguide and μ is a zero solution of the proper Bessel function. Values of μ are tabulated for the first 700 modes in Bell System Technical Journal, May, 1958 on pages 689 et seq. The complete 700 modes will be reprinted in the forthcoming *"the microwave engineers' handbook and buyers' guide"* to be published by *the microwave journal.*

	Mode	μ	$\frac{\lambda_c}{a}$
1	TE 1-1	1.841	3.413
2	TM 0-1	2.405	2.613
3	TE 2-1	3.054	2.057
4-5	TM 1-1	3.832	1.640
4-5	TE 0-1	3.832	1.640
6	TE 3-1	4.201	1.496
7	TM 2-1	5.136	1.223
8	TE 4-1	5.318	1.181
9	TE 1-2	5.331	1.179
10	TM 0-2	5.520	1.138
11	TM 3-1	6.380	0.985
12	TE 5-1	6.416	0.979
13	TE 2-2	6.706	0.937
14-15	TM 1-2	7.016	0.896
14-15	TE 0-2	7.016	0.896
16	TE 6-1	7.501	0.838
17	TM 4-1	7.588	0.828
18	TE 3-2	8.015	0.784
19	TM 2-2	8.417	0.746
20	TE 1-3	8.536	0.736
21	TE 7-1	8.578	0.732
22	TM 0-3	8.654	0.726
23	TM 5-1	8.771	0.716
24	TE 4-2	9.282	0.677
25	TE 8-1	9.647	0.651
26	TM 3-2	9.761	0.644
27	TM 6-1	9.936	0.632
28	TE 2-3	9.969	0.630
29-30	TM 1-3	10.173	0.618
29-30	TE 0-3	10.173	0.618
31	TE 5-2	10.520	0.597
32	TE 9-1	10.711	0.587
33	TM 4-2	11.065	0.568
34	TM 7-1	11.086	0.567
35	TE 3-3	11.346	0.554
36	TM 2-3	11.620	0.541
37	TE 1-4	11.706	0.537
38	TE 6-2	11.735	0.535
39	TE 10-1	11.771	0.534
40	TM 0-4	11.792	0.533

NOMOGRAM

For Determining Cutoff Wavelength in Circular Waveguide

BURRELL R. HATCHER
CHU ASSOCIATES
Littleton • Massachusetts



This nomogram is used to determine one of the following quantities when the other two are known:

1. radius (in inches) of the circular waveguide
2. the cutoff wavelength (in inches or centimeters)
3. the mode of propagation (for the first nine electric or magnetic modes)

The scale on the left, *a,* is the inner radius of the waveguide in inches. The scale on the right is the cutoff wavelength, and is calibrated in inches and centimeters. The diagonal scale gives the mode of propagation.

If the nomogram does not cover the desired range of *a* and λ_c, multiply those two scales by a constant 10^n.

For example, in a waveguide having an inner radius .75 inches, propagating in the TM_{01} mode, the cutoff wavelength is 4.98 cm. (1.96 inches).

MINIATURE

BAND PASS

& LOW PASS

RF FILTERS

TELONIC'S new TBP Band Pass Filters cover the frequency range from 200 to 2000 megacycles and may be easily set to any bandpass value between 2.5% and 25%. They are available with 2, 3, or 4 sections depending on bandpass and rejection requirements. Electrical performance of the TBP filters corresponds to resonant cavities or tank circuits with unloaded Q's of over 200, and their DC resistance is essentially infinite both to ground and from input to output.

Small size and rugged construction make these filters ideal for missile and aircraft applications. Special temperature resistant coil-forms and spacers assure a high degree of mechanical stability and allow operation at temperatures over 100°C. Available with BNC or other standard connectors.

Typical specifications for a 4-Section Filter

Center Frequency	200-2000 mc.
Pass Band Width	2.5-25%
Pass Band Attenuation	0.5 db ± .2 db per section at 3% B.W. 0.2 db ± .1 db per section at 12.5% B.W.
Pass Band VSWR	Less than 1.5:1
Impedance Nominal	50 ohms
Power Input	Over 15 watts
Connectors	Type BNC, TNC or N
Material	18% Silver Nickel
Weight	Approximately 5 ounces

Price — $125.00 to $30.00 depending on type and quantity.

MINIATURE LOW PASS FILTERS

Telonic also manufactures the TLP Series of Low Pass RF Filters exhibiting the same quality and high degree of performance as in the band pass units. These Low Pass Filters are available for any cut-off frequency from 200 to 2000 mc in 5 mc increments.

Telonic ENGINEERING CORP.
Laguna Beach, California

For complete data on both types write for data file TE-1

Circle Reader Service Card 55

New Products

(Continued from page 99)

tions as small as one micron and is capable of utilizing time resolutions down into the sub-millimicrosecond region to the limits of the EG&G TW deflection tube.

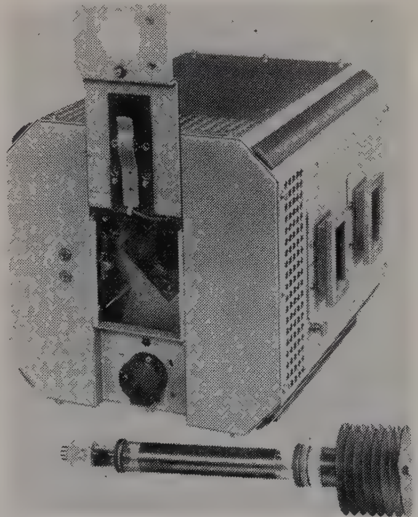
The trace on the face of the TW tube is reproduced on a prescaled sheet of graph paper so that the time base and amplitude can be read immediately. Almost any X-Y recorder may be used. Sensibility of the trace is increased about 15 times. X and Y axis settings are independent of each other and magnification of the axes is arbitrarily adjustable as determined by the recorder.

The design of the photo-electric pickup eliminates many of the problems encountered in optical recording. Traces of extremely high resolution are reproduced as all optical distortion of the image is eliminated no accuracy is lost in converting the pulse from the cathode ray tube to electrical X-Y analogs. Sensibility of 60 millivolts per trace width on the tube is increased to 4 millivolts per trace width on the plot. Any trace or any particular section of a trade may be scanned and magnified to obtain full scale recorder drawings of deflections as small as one micron.

Circle Reader Service Card 116

—mwj—

UNATTENDED MICROWAVE STATIONS SERVED BY WAVE TUBE



Amperex Electronic Corp., Hicksville, Long Island, has announced the type of 55340 traveling wave tube. Guaranteed for a minimum life of 6000 hours, and operating as a broad band amplifier in the 3800 to 4200 Mc range, the 55340 is suited for unattended microwave stations.

Mount and tube are so designed that input and output circuits remain matched when a new tube is inserted in the mount.

The 55340 can deliver a saturated power output of eight watts. The low level gain at 4200 Mc, with the output power at 100 mw, is better than 37 db. With the output power at three watts, the gain i better than 35 db. The noise figure is les than 30 db.

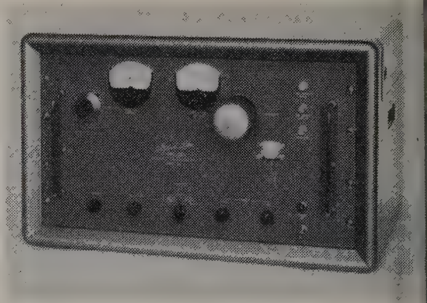
The wave propagating structure is o the helical type. Electron beam focusin is by means of a permanent, uniform fiel magnet. The mount couples to standar rectangular waveguide WR 229. Due t the magnet configuration the mount i completely shielded, and mounts can b stacked or operated adjacent to on another without additional shielding.

The tube is free air, convection coole No special cooling equipment is require The 55340 operates at 1100 volts, whic simplifies power supply problems.

Circle Reader Service Card 117

—mwj—

MILLIMETER RANGE STABILIZED SIGNAL GENERATOR ANNOUNCE



Strand Labs, Newton, Mass., announce a millimeter range signal generator pro viding high stability and power outpu Designated the Model 100, this signa generator is the most recent addition to a line of stabilized signal generators pro viding frequency coverage from L-Ban to K-Band.

The performance characteristics of th Model 100 Stabilized Signal Generato are as follows: Frequency Range, 32. kMc to 37.5 kMc (K_A-Band); Frequency Stability, Short Term —0.01 part pe million, Long Term — 1 part per million Average Power Output, 15 mw.

The Model 100 Stabilized Signal Generator is also available in a configuratio suitable for rack-mounting.

Circle Reader Service Card 118

—mwj—

MOTOROLA INTRODUCES 12 KMC RF EQUIPMENT

Motorola, Inc., Chicago, Ill., has an nounced a new 12,000 Mc microwav receiver-transmitter. The RF equipment Model MR-40, provides broad-band com munications particularly suited for ver high speed data transfer as well as trans mission of conventional telephone an teletypewriter messages.

The new microwave package can carr data at 62,000 characters per second whe used in conjunction with Motorola's ne data transmission multiplex system. Thi speed, 20 times faster than the capacit of wire lines, facilitates linking informa on gathering and programming facilities central computers.

Data transmission utilizes only a ortion of the carrier beam provided by IR-40. It can also handle voice, facsimile nd teleprinter transmissions as well as ontrol and monitor functions with 600 r more multiplexed channels.

The MR-40 unit provides 100 milliwatts f power output. Basic components of the quipment are two reflex klystron tubes, ne in the receiver and one in the transitter. Each has a life expectancy of 20,000 ours of continuous operation. The reeiver-transmitter can be used with both irectly aimed dish antennas and towernounted passive reflector configurations.

Circle Reader Service Card 119

—mwj—

VOLTAGE, CURRENT REGULATED POWER SUPPLY OFFERED BY TRYGON ELECTRONICS

Trygon Electronics, Inc., Roosevelt, .. I., announces the expansion of the rylab series with the availability of the 50-750 laboratory supply. Furnishing -50 VDC at 0-750 ma, this unit provides oth constant voltage and constant curent from a single supply. Both voltage nd current regulation is better than .05 per cent, while the voltage ripple is ess than 0.5 millivolts and the current ipple less than 0.01 per cent. Since the nit is adjustable down into the low milliolt region, it makes an ideal supply for unnel diode applications.

The T50-750 has adjustable current miting short circuit protection, thus ssuring complete control of the output urrent even under short circuit conditions.

Remote sensing and remote programing over the entire voltage range in the oltage mode and remote programming ver the current range in the current mode ; included in the standard unit.

All power transistors have been preged for at least 500 hours in order to ptimize their reliability. Electrolytic apacitors are of computer quality, thus llowing an operating ambient temperaure up to 50°C and a storage temperature p to 85°C.

Price for the Trylab series is $199.50 nd delivery is four weeks ARO.

Circle Reader Service Card 120

—mwj—

WESTREX CORPORATION ANNOUNCES A SINGLE SIDEBAND RECEIVING SYSTEM

Flexibility, modular construction, high stability and low intermodulation distortion are provided by a new single sideband strip receiver introduced by Westrex Corp., a division of Litton Industries.

The basic receiver is designated Type 600 and has continuous coverage in the 1.7 to 32 Mc range. RF, IF and power supply modules are basic to the system. Additional modules are available for multiplexed voice signals, circuit testing, frequency shift multiplexed teleprinter signals, A F C, frequency synthesizer and RF module switching. A module is also available for diversity combining.

Each module is a light-weight and rugged standard fractional ATR series aircraft housing of cast aluminum. RF and IF modules are 1/4 ATR size, power supplies 3/8 ATR. The modules are mounted on a tray type panel 19 inches wide, 15 inches deep and 8 3/4 inches high, which may be rack or cabinet mounted, including aircraft and mobile installations.

Control, power and circuit test conductors are terminated in plug-in connectors at the back of each module. Antenna and IF interconnections are made at front-panel TNC fittings.

Circle Reader Service Card 121

—mwj—

MICROWAVE DUPLEXER USING SECONDARY ELECTRON RESONANCE DEVELOPED BY G.E.

An S-band duplexer capable of switching seven megawatts of incident peak power has been developed by General Electric Co., Palo Alto, Cal.

The new duplexer, in which power-activated switching is accomplished by secondary electron resonance (multipactor) rather than by gas discharge, is reported to feature long life, low noise, and short recovery times of the order of an RF cycle.

Multipactor discharge consists of electrons in high vacuum which are driven back and forth between two electrodes by an RF electric field.

In the prototype duplexer, the multipactor discharge occurs in an evacuated transmission type cavity, which performs the functions of a TR switch.

Development work performed to date has resulted in design and operation of such TR cavities capable of switching 3.5 megawatts of incident power upon the

(Continued on page 104)

AEL
MICROWAVE COMPONENTS

WAVEGUIDE CRYSTAL DETECTOR MOUNTS

AEL proudly offers a new line of microwave WAVEGUIDE CRYSTAL VIDEO DETECTOR MOUNTS specifically designed for the High Tangential Sensitivity that has become the hallmark of AEL's detector mount program. Available for X, Ku, K and Ka bands.

Coaxial crystal detector mounts • 50 mc to 12 kmc

Waveguide Filters Band Pass and High Pass • 8.2 kmc to 40 kmc

Microwave Crystal Switches • 10 mc to 14 kmc

Horn Antennas Linearly or Circularly polarized • 1 kmc to 40 kmc

AEL®

AMER. ELECT. LABS., INC.
121 N. 7TH ST., PHILADELPHIA 6, PA.
In Canada contact: Conway Electronic Enterprises Regd. Toronto, Canada

Circle Reader Service Card 56

(Continued from page 103)

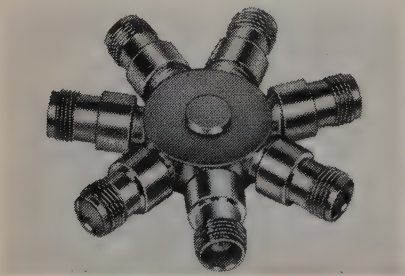
the cavity and of providing isolation of 23 db.

A dual TR cavity consisting of two similar resonators has been built which, in conjunction with two side-wall hybrids, constitutes a balanced duplexer capable of switching seven megawatts.

Circle Reader Service Card 122

—mwj—

MICROLAB OFFERS SIX WAY MICROWAVE POWER DIVIDER



A six way resistive power divider has been announced by Microlab, Livingston, N. J., as part of its new line of dividers.

The six way dividers consist of seven symmetrical arms (one input, six output) spaced radially about a hub. Resistive networks within the arms provide impedance matching up to 3000 Mc. The unit is electrically symmetrical, and any arm or arms can be used as inputs, the remaining arms being used for outputs.

The dividers are normally furnished with all female connectors in either the N, BNC, TNC, C or HN series, but they can also be supplied with any combination of male and female connectors. They have an input and output VSWR of 1.2, and impedance of 50 ohms, a power rating of 2 watts, and are designed to meet the requirements of MIL-E-5272.

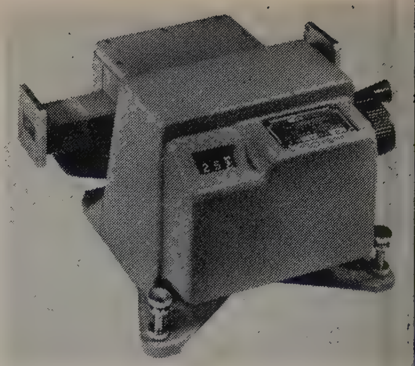
The six way power dividers are priced at $90 to $105 depending on connectors and are available for immediate delivery from stock. They are a part of Microlab's new complete line of resistive and reactive dividers with two to six outputs.

Circle Reader Service Card 123

—mwj—

NARDA DEVELOPS PRECISION VARIABLE ATTENUATORS WITH DIGITAL READOUT

Two digital readout precision variable attenuators covering X-Band and C-Band have been developed by the Narda Microwave Corp., Mineola, L. I. Operating over the full waveguide frequency range, these attenuators feature a digital counter that reads directly in decibels and tenths of decibels. No interpolations are needed, and the figures can be read at a glance.



The units are constructed with a moveable "lossy dielectric" ridge that provides 0 to 60 db attenuation with flat frequenc response. The ridge is driven by a spring loaded precision cam and the digit counter is geared directly to the cam shaft, insuring complete freedom fro backlash.

In addition to the convenience provide by the digital counter, these new pre cision attenuators also boast such advan tages as shorter length, much higher pow er-handling capabilities, greater rugged ness, and a drive housing which acts as supporting stand.

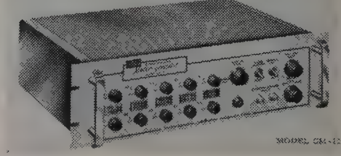
The maximum calibration error is ± per cent or 0.2 db, whichever is greate to 50 db; ±3 per cent from 50 to 60 db Maximum attenuation is approximately 6 db.

Model 780, selling for $250, covers 8. to 12.4 kMc; Model 783, covering 3.9 to 5.8 kMc, is priced at $425. Both mode have a maximum VSWR of 1.2 and a available from stock.

Circle Reader Service Card 124

—mwj—

MORE MARKING INDICATIONS ATTAINED



Jerrold Electronics Corp., Philadelphi Pa., has developed two crystal controlle marker generators, models CM-6 an CM-10, which, though they contain si and ten crystal oscillators respectivel use harmonic and side band techniques t attain more marking indications.

Utilizing a single center frequen oscillator, it is possible to choose tw side band oscillator frequencies to provi a total of five marks, one at the cent frequency, two at the band edges and tw at the 3 db down points.

The CM-6 is a six-crystal unit house

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PIlgrim 8-4700

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r a portable cabinet and the CM-10 is a 0-crystal unit developed for rack mountng. Both provide frequency references on esponse curves of filters, amplifiers and ther equipment requiring a predeternined frequency specification.

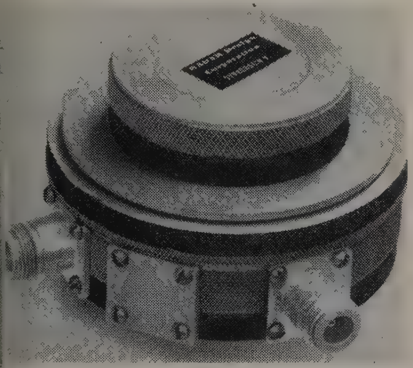
The output amplitude of each oscillator s individually controlled. The generators re also equipped to provide dc marker ndications, necessary when using "X-Y" ecorders. A 40 db variable gain oscillocope preamplifier is provided to facilitate esponse measurements of higher attenuaion devices. In addition, provision is nade to switch in a high pass audio filter o improve the sensitivity and display of vide band VSWR measurements.

The CM-6 is priced at $285; the CM-10 ells for $425.

Circle Reader Service Card 125

—*mwj*—

STUB POSITION CHANGED BY ROTATING KNOB



Radar Design Corp., Syracuse, N. Y., as announced model 1140 rotary microave tuner, a roving stub tuner whose tub position is changed by rotating a nob. A second (concentric) knob adusts stub length.

Any impedance can be matched to its 0 ohm (type N) system in the 900 Mc – 12,400 Mc range. Price is $195.00, and elivery is three weeks.

Circle Reader Service Card 126

—*mwj*—

DIODES DESIGNED FOR ULTRASONIC AIRCRAFT

Sylvania Electric Products Inc., Woburn, Iass., has announced a matched pair of igh altitude silicon microwave mixer iodes designed for use in ultrasonic airraft and missile applications.

Marvin E. Groll, product sales manager – microwave diodes, for Sylvania's Semionductor Division, said the new hernetically sealed diodes (Type 1N53D and s reversed polarity version 1N53RD are a-band (34,000 mc) units with maximum perating temperature of 150-degrees entigrade, overall noise figure of 9.0 db, nd an amplifier noise figure of 1.5 db. oth feature VSWR maximum (to a 65 hm holder) of 1.5 at 34,860 mc, and 2.5 naximum at plus and minus six per cent. Jse of the matched pair virtually elimiates local oscillator noise, Mr. Groll dded.

In quantities of 1-99, type 1N53D is riced at $75, type 1N53RD at $110.

Circle Reader Service Card 127

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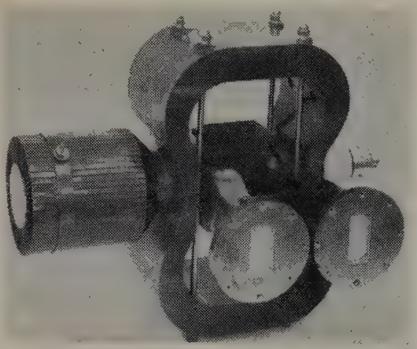
VARIAN OFFERS VA 834B AMPLIFIER KLYSTRON



Lightweight, air-cooled and compact, the new VA 834B amplifier klystron by Varian Associates, Palo Alto, Cal., gives one kilowatt of CW power tunable from 4.4 to 5.0 kMc.

For transportable systems, air cooling and permanent magnet focusing of the power amplifier tube allows savings in weight. Heat exchangers, magnet power supplies and their control circuits are eliminated. Operating procedures are simplified by elimination of focusing and coupling adjustments.

The VA 834B was specifically designed for tactical and transportable field equipment. It is suited to tropospheric forward scatter communications and radar transmitters. Maximum weight, including magnet, is 60 pounds. Maximum dimensions are 12 inches x 13 inches x 15 1/2 inches.

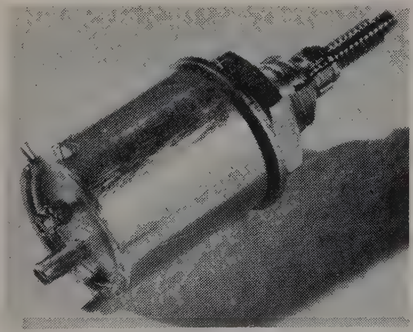
The tube tunes over a range of 600 Mc. Synchronously tuned at 4.4 kMc, a gain of 57 db is obtained. Tuned for wideband use, a bandwidth of 12 Mc is obtained.

In small quantities, the price is $9980, available from stock.

Circle Reader Service Card 128

—*mwj*—

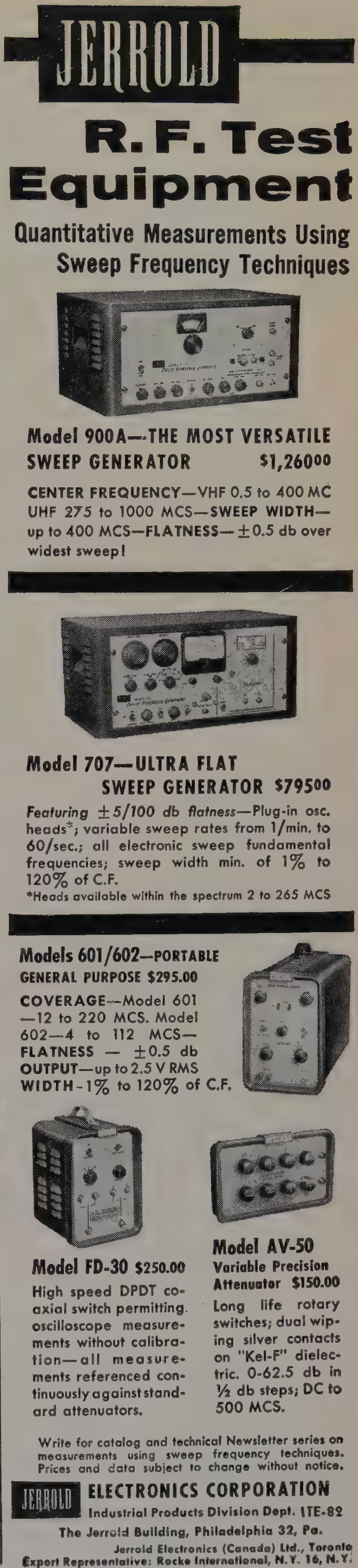
SHIELDED RF INDUCTORS BY NORTH HILLS ELECTRONICS ANNOUNCED



North Hills Electronics, Glen Cove, L. I., has announced a new series of slug-tuned, shielded RF Inductors. Designated as the series 900, these units are designed for military and high quality commercial applications. The series covers a range of inductance from 0.5 μh to 100 μh in 10 steps and is most useful over the 0.5 to 60 Mc spectrum where the average Q is 70.

The assembly consists of powdered iron cups and core mounted in a plated brass

(Continued on page 106)



JERROLD

R. F. Test Equipment

Quantitative Measurements Using Sweep Frequency Techniques

Model 900A—THE MOST VERSATILE SWEEP GENERATOR $1,260.00

CENTER FREQUENCY—VHF 0.5 to 400 MC UHF 275 to 1000 MCS—SWEEP WIDTH—up to 400 MCS—FLATNESS—±0.5 db over widest sweep!

Model 707—ULTRA FLAT SWEEP GENERATOR $795.00

Featuring ±5/100 db flatness—Plug-in osc. heads*; variable sweep rates from 1/min. to 60/sec.; all electronic sweep fundamental frequencies; sweep width min. of 1% to 120% of C.F.

*Heads available within the spectrum 2 to 265 MCS

Models 601/602—PORTABLE GENERAL PURPOSE $295.00

COVERAGE—Model 601—12 to 220 MCS. Model 602—4 to 112 MCS—FLATNESS — ±0.5 db OUTPUT—up to 2.5 V RMS WIDTH-1% to 120% of C.F.

Model FD-30 $250.00

High speed DPDT coaxial switch permitting oscilloscope measurements without calibration—all measurements referenced continuously against standard attenuators.

Model AV-50 Variable Precision Attenuator $150.00

Long life rotary switches; dual wiping silver contacts on "Kel-F" dielectric. 0-62.5 db in ½ db steps; DC to 500 MCS.

Write for catalog and technical Newsletter series on measurements using sweep frequency techniques. Prices and data subject to change without notice.

JERROLD ELECTRONICS CORPORATION
Industrial Products Division Dept. ITE-82
The Jerrold Building, Philadelphia 32, Pa.
Jerrold Electronics (Canada) Ltd., Toronto
Export Representative: Rocke International, N.Y. 16, N.Y.

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arra π LINE CONTINUOUSLY

VARIABLE MINIATURE VAMP ATTENUATOR

arra
π LINE VAMP ATTENUATOR
MODEL
SERIAL
RADOME RESEARCH
WESTBURY N.Y.

Exclusive Features:

- Size: 3" diameter x 1⅛" high excluding connectors and knob.
- Full range of attenuation in less than 165° rotation.
- Frequency Bands: from 2.5 KMC to 9.6 KMC.
- Attenuation Range:
  X Band—50 db
  C Band—35 db
  S Band—20 db
- VSWR: 1.5 Maximum for all values of attenuation, 1.3 for specific bands.
- Insertion loss less than 0.5 db
- Continuously Variable for all values of attenuation.
- Calibration plate in 1° increments or directly calibrated.
- Positive locking device.
- Adaptable for manual, servo, or remote control.
- Type N Male or Female connectors.
- Power Capacity: 10 watts average; up to 5 KW peak.

arra Antenna & Radome Research Associates
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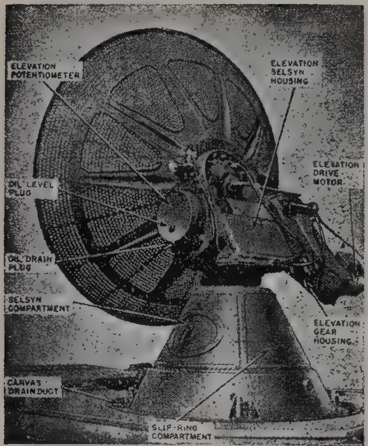


ANTENNA PEDESTAL SCR 584—MP 61B

Full azimuth and elevation sweeps. 360 degrees in azimuth. 210 degrees in elevation. Accurate to 1 mil. or better over system. Complete for full tracking response. Angle acceleration rate: AZ. 9 degrees per second squared EL.4 degrees per second squared. Angle slewing rate: AZ 20 degrees per sec. EL. 10 degrees per sec. Angle tracking rate: 10 degrees per sec. Includes pedestal drives, selsyns, potentiometers, drive motors, control amplidynes. Excellent condition. Quantity in stock for immediate shipment. Ideal for missile & satellite tracking, antenna pattern ranges, radar systems, radio astronomy, any project requiring accurate response in elevation and azimuth.
Complete description in McGraw-Hill Radiation Laboratory Series, Volume I, page 284 and page 209, and Volume 26, page 233.

RADIO RESEARCH INSTRUMENT CO.
550
FIFTH AVE.
NEW YORK
JUDSON
6-4691

Circle Reader Service Card 60

New Products

(Continued from page 105)

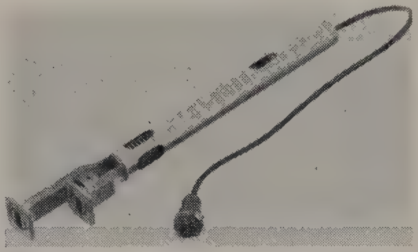
case. The windings are sealed with epoxy. A built-in tension device locks the slug in place. A single threaded ¼ inch-28 bushing results in a single and sturdy mounting. The housing is 7/16 inch O.D.

Designed for use in IF and RF Amplifiers, these inductors can be used in telemetering, radar, and communications equipment. Units are carried in stock.

Circle Reader Service Card 129

—*mwj*—

MICROWAVE AMPLIFIERS PRODUCED



Microwave Electronics Corp., Palo Alto, Cal., now has in production a new K_u-band solenoid-focused traveling-wave amplifier. The power output rating is 1 watt minimum; however, the tubes have shown test capabilities up to 6 watts output in the center of the frequency band. The standard frequency range is 12 to 18 kMc with a minimum small signal gain of 30 db. The small signal gain variation over the band is less than 8 db.

Metal-ceramic construction is used throughout. The encapsulated tube weighs 1 ¾ pounds and is 1 ⅛ inches in diameter and 14 ¾ inches long, including input and output waveguides.

The tube has been designated the M2405-A and is priced at $3,000 each in small lots; delivery is 30 days after receipt of order.

Circle Reader Service Card 130

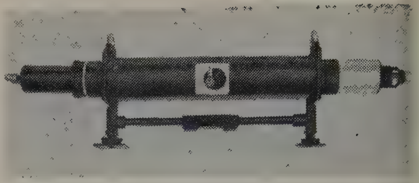
—*mwj*—

HUGHES DEVELOPS HIGH GAIN TWT AMPLIFIERS

Hughes Aircraft Company's microwave tube division, Los Angeles, Cal., is now producing two new X-Band high gain traveling-wave amplifiers capable of 10 to 100 times the average power of conventional helix tubes, Dr. Lester M. Field, division manager, has announced.

The power increase is achieved by use of folded waveguide structures to replace the helix and special periodic focusing techniques, he explained.

The Hughes 307H has a 100 kw peak power output (500 watt average) with a minimum of 50 kw over an 8.5 - 9.5 kMc frequency range. It has 54 db saturation gain and operates with a 38 kv beam voltage. Maximum duty cycle is one per cent.



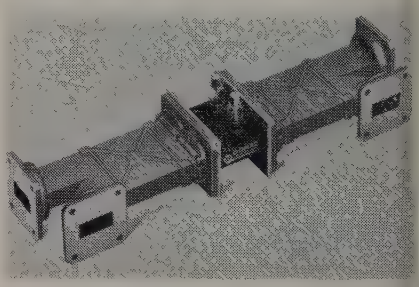
The 307H is engineered of metal and ceramic materials, with all-heliarc welded gun and window assemblies, long-life dispenser-type cathodes, and integrally designed ion pumps. Its total weight including periodic magnets is 21 lbs.

"This tube can readily be applied as a driver for crossed-field output amplifiers, or as an efficient single-tube transmitter, light and compact enough to fit into a cramped environment," Dr. Field said. "Its average rf power rating of 500 watts makes it a useful companion for many types of microwave output stages now under development."

Circle Reader Service Card 131

—*mwj*—

BOMAC OFFERS BALANCED WAVEGUIDE DUPLEXERS



The new balanced waveguide duplexers offered by Bomac Laboratories, Inc., Beverly, Mass., feature several advantages in radar performance when compared to systems using branch line duplexers for broadband application.

These advantages include minimum incoming signal loss to the receiver because the broadband ATR action prevents return signal loss to the transmitter when the TR tubes are unfired; matching over a much broader frequency range than is possible with the branched duplexer; and greater protection against receiver crystal burnout, since much of the leakage power from the TR tubes is dissipated in the terminated arm, with little power being coupled to the receiver.

Units are available in X, L, S, C, Sl, Ku, K and Ka Bands.

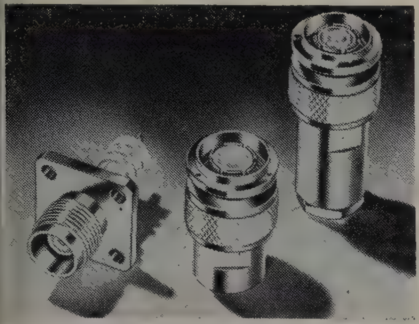
The X-Band Duplexer is rated as follows: frequency, 8490 - 9578 Mc; transmitter power, 200 kw maximum; Duplexer Loss, 1.2 db maximum; isolation, 10 db minimum; VSWR, 1.4 maximum, and VSWR high level, 1.2 maximum.

Circle Reader Service Card 132

—*mwj*—

LOWER COST, HIGH RELIABILITY RF CONNECTORS DEVELOPED

Designed for use with small size coaxial cables, such as RG-59B/U, the new series of "AN/MS" Type connectors developed by National Connector Corp., Minneapolis, Minn., is the first available line of connectors of this type to use irradiated polyolefin and polypropylene—both less costly than the more commonly used flourocarbon materials.



Weatherproofed and designed for extreme reliability, even under abnormal conditions of stress, NCC's "AN/MS" series connectors may be efficiently used up through microwave frequencies with a minimum of line unbalance or increase in standing wave ratio. Their unique design permits the coax conductor to be soldered directly to the contact point within the connector body, greatly reducing the danger of accidental disconnection due to cable strain.

The new connectors are available in impedances of 50 and 75 ohms and have maximum voltage ratings up to 2500 volts.

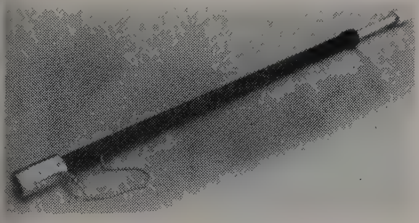
Circle Reader Service Card 133

— m w j —

RADAR DESIGN CORP. INTRODUCES TWO COAX SLIDING LOADS

Radar Design Corp., Syracuse, N. Y., announces the development of two new coax sliding loads.

The Model 736 LT Load is a sliding termination for the 1500 - 6000 Mc frequency range. The moving element VSWR is less than 1.05. Available with either plug or jack type input connector, the Model 736 has a single order price of $275 and has a three to five week delivery.



The Model 1113 Sliding Load is designed for the frequency range 1 - 8 kMc range. Equipped with a type N input connector, the Model 1113 has a maximum VSWR of 1.10 (1.05 maximum at 2 kMc and above) which is entirely associated with the sliding element.

Circle Reader Service Card 134

— m w j —

(Continued on page 108)

a big step forward in broadband RF amplification

OCTAVE RF AMPLIFIERS

40 to 600 mcs

- low noise figure
- low power drain
- high gain
- broadband operation
- flat gain characteristic

Model HFW Octave RF Amplifiers feature low noise, high gain, low power drain *plus* dependability and easy maintenance. Four basic amplifiers are available, with the following frequency responses:

40 to 80 mcs • 80 to 160 mcs
160 to 320 mcs • 300 to 600 mcs

Two additional units cover the 100-400 mcs region as follows:

100 to 200 mcs • 200 to 400 mcs

Conservatively speaking, these equipments offer a practical and realistic answer to nearly all broadband amplification requirements.

TYPICAL PERFORMANCE CHARACTERISTICS Model HFW-303

Input frequency:	300-600 mcs
Input, output impedance:	50 ohms
Input, output V.S.W.R.:	Less than 1.5 in bandpass region
Noise figure (average):	7 db
Gain	30 db
Primary power requirements:	115 VAC, 60 cps
Size (L.W.H.):	19" x 12½" x 7"
Mounting dimensions:	Standard 19" relay rack

Write for further information.

Applied Research inc.

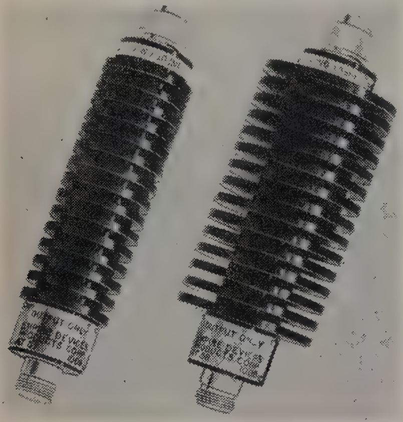
76 South Bayles Avenue, Port Washington, N. Y.

Circle Reader Service Card 10

New Products

(Continued from page 107)

10 AND 15 WATT MICROWAVE ATTENUATORS DEVELOPED BY EMPIRE DEVICES



Models AT-57 and AT-58 power attenuators, developed by Empire Devices Products Corp., Amsterdam, N. Y., are intended for the frequency range from dc to 2000 Mc. Model AT-57 is rated at 10 watts continuous and 5 kw peak, while Model AT-58 will dissipate 15 watts continuous and 5 kw peak.

Both attenuators have a maximum VSWR of 1.2:1; an accuracy of ±0.25 db up to 1000 Mc, and of ±0.5 db from 1000 Mc to 2000 Mc. Input and output impedance is 50 ohms. Each can be furnished in any one of 10 standard attenuation ratios from 1 to 10 db.

In addition to Models AT-57 and AT-58, a variety of other Empire attenuator pads cover frequency range from dc to 10,000 Mc. Six and 12 position step attenuators for the frequency range from dc to 10,000 Mc are also available.

Circle Reader Service Card 137

—mwj—

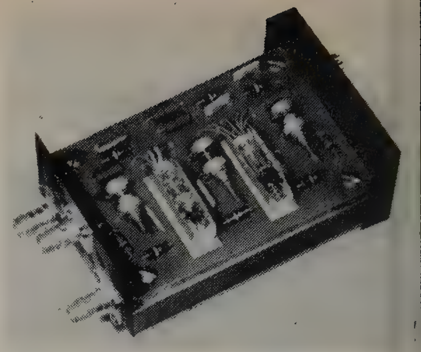
ORION OFFERS MICROWAVE MIXER-PREAMPLIFIERS

A series of Microwave Mixer-Preamplifiers designed for operation from below 0.25 to above 17 kMc are now being offered by Orion Electronic Corp., Tuckahoe, N. Y.

Each unit of this series "I" covers a band of frequencies; the eleven units offer complete coverage of the popular bandwidths. The units consist of either a coaxial or waveguide mixer in conjunction with a low noise preamplifier packaged in a single unit.

Each model can be supplied with a low noise Preamplifier using miniature or sub-miniature tubes or transistors.

The VSWR for the Signal and Local Oscillator inputs is from 1.2 to 2.2 depending upon the frequency range and



type of mixer selected.

Each model can be obtained with eithe a single ended or balanced input, a symmetrical bandpass, specified bandwidth gain and noise figure. These values depen upon the RF and IF frequencies involve and can only be specified for a particula application.

Price and availability are available on request.

Circle Reader Service Card 138

—mwj—

MACHLETT DESIGNS HIGH-MU, PLANAR TRIODE

A triode designed as an oscillator frequency multiplier or power amplifier i radio transmitting service has been announced by The Machlett Laboratories Inc., Springdale, Conn., a subsidiary o Raytheon Company.

The ML-7698 is a high-mu, plana triode with a frequency range up to 3000 Mc. Featuring low inter-electrode capacitance, high transconductance, and high mechanical strength, the tube has a compact, metal and ceramic coaxial construction making it well suited for operation in line-type circuits at lower frequencies as well as in cavity resonators at the higher frequencies.

The cathode is an indirectly-heated oxide-coated disc and the anode is cooled by conduction and convection. Availability of the unit is 60 days; cost is $100.

Circle Reader Service Card 139

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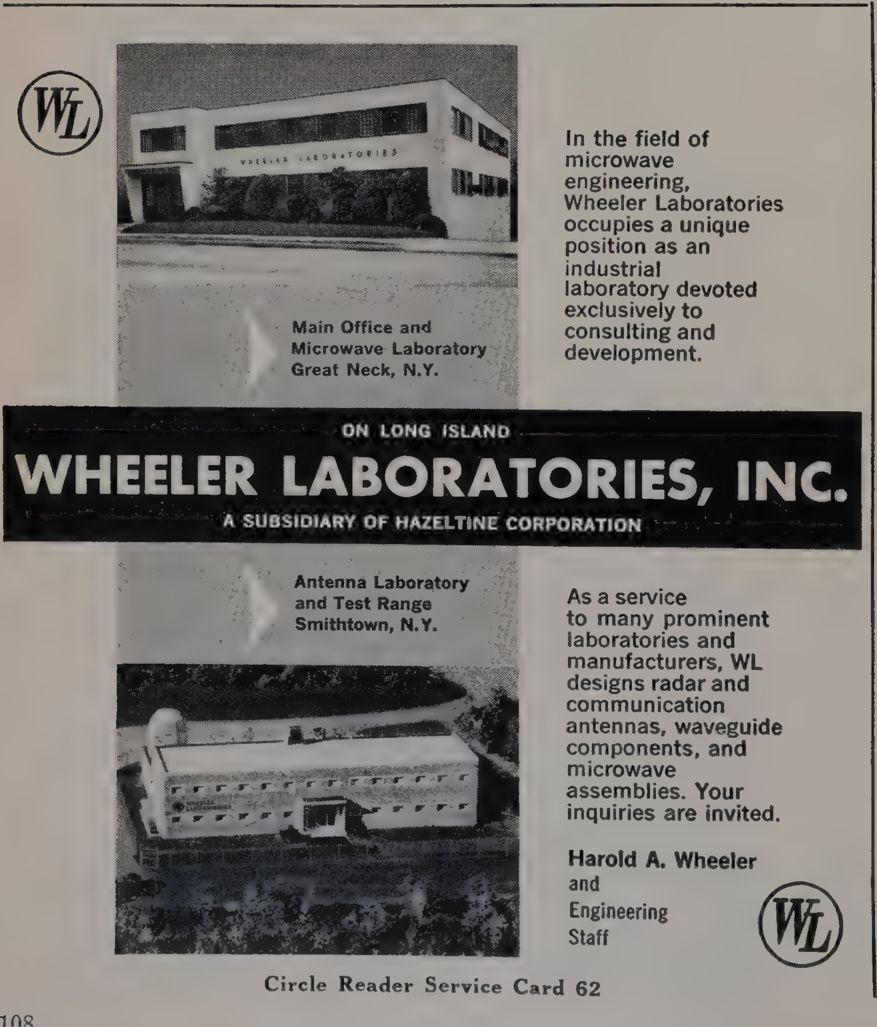

In the field of microwave engineering, Wheeler Laboratories occupies a unique position as an industrial laboratory devoted exclusively to consulting and development.

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Antenna Laboratory and Test Range
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As a service to many prominent laboratories and manufacturers, WL designs radar and communication antennas, waveguide components, and microwave assemblies. Your inquiries are invited.

Harold A. Wheeler
and
Engineering
Staff

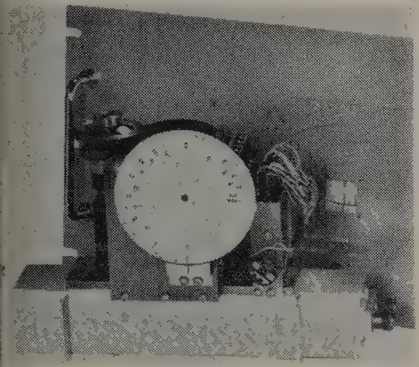
Circle Reader Service Card 62

TRANSCO ANNOUNCES C-BAND ATTENUATOR

A direct reading 0-100 db C-Band attenuator has been announced by Transco Products, Inc., Los Angeles, Cal.

The unit has coaxial type N connectors and is motor actuated from 0 to 100 db in less than 50 seconds. Attenuation is accomplished by inserting 2 glass cards transversely into waveguide. The direct reading dial is accurate to 0.1 db or ±1 per cent of dial reading at calibration frequency.

Actuation is accomplished by means of a two way switch with spring return to a neutral position and/or switch selection of 5 present positions between 0 and 100 db.



VSWR is under 1.5 from 5.0 to 5.8 kMc (Under 1.1 at one frequency), insertion loss is 1.0 db maximum. The 19 inch rack-mountable panel shown is optional. Another option offers waveguide flanges instead of coaxial connectors.

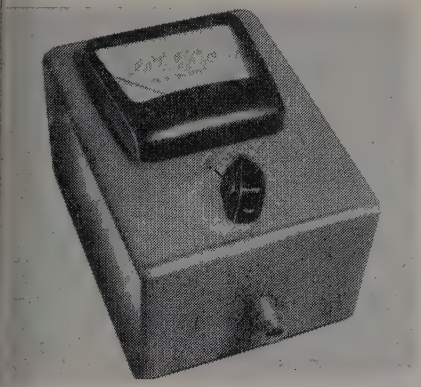
Circle Reader Service Card 140

—mwj—

ELECTRO IMPULSE LABORATORY EXPANDS LINE OF LOW-POWER RF POWER METERS

Electro Impulse Laboratory, Inc., Red Bank, N. J., announces three new additions to its line of low-power RF Power Meters. Measuring from 2 to 700 Mc, they include Model PM-4, 150 and 600 milliwatts full scale; Model PM-5, 500 and 1500 milliwatts full scale; and Model PM-6, 1.5 to 6 watts full scale.

These broadband Power Meters are of the absorption-type consisting of an air cooled, coaxial load resistor and a voltmeter calibrated to read watts. They are suitable for use as field or laboratory test instruments, are completely shielded and non-radiating, permitting transmitter testing and adjustment without interference. No correction curve is necessary to cover the frequency range. Accuracy is plus or minus 5 per cent. The three models are priced at $95 each.



Circle Reader Service Card 141

—mwj—

TRANSISTOR MODULAR AMPLIFIERS ANNOUNCED BY ORION

Orion Electronic Corp., Tuckahoe, N. Y., announces the development of its new IF Transistor Modular Amplifiers, Series B.

The modular construction of the unit amplifiers allows for an accurate but inexpensive method of breadboarding IF amplifiers with great flexibility in gain, power output, and bandwidth.

The new series of units have a gain of 10 db at 30, 45, and 60 Mc, and an input and output impedance of 50 ohms. Units can be supplied with 5, 25, 75, or 300 milliwatts capability. The five-milliwatt modular unit can be AGC'd over most of its power range.

The amplifiers have a bandwidth of 6 Mc, but can be supplied at others if required.

The modules operate from a 28 ± 2 volts positive dc source and have a current requirement of 2 to 40 milliamperes depending upon the output power of the unit.

Upon special request, modules can be supplied which will have gating capabilities of up to 2 microsecond pulses with a rise time of .25 microseconds or less.

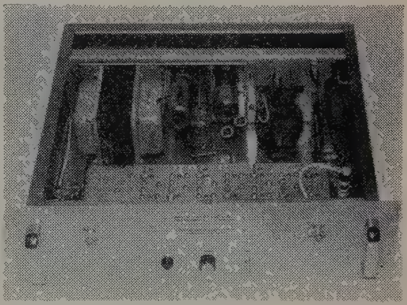
A rack can be supplied for the plug in modules which will be capable of mounting up to eight of the units. This rack will enable the use of only one power connection and a single AGC voltage to be supplied to the modular units.

Price is $125 to $150 depending upon power output, and availability is two to four weeks.

Circle Reader Service Card 142

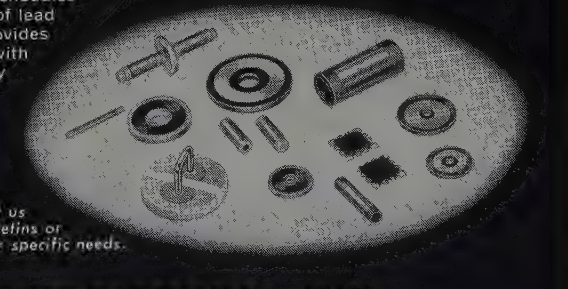
—mwj—

BROADBAND AMPLIFIER BY APPLIED RESEARCH COVERS 490 MCS TO 1000 MCS



Applied Research Inc., Port Washington, N. Y., announces the availability of its Model HFW-8(A)-49100 broadband amplifier, covering an octave range of fre-

(Continued on page 110)



A STEP BEYOND
- in precision film resistors

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Produced to Precise Standards of Manufacture

Custom designs—including rod, disc and special shapes on glass, ceramic, mica, and plastic substrates—produced economically to your specifications. Deliveries are timed to keep step with your production schedules with only a minimum of lead time required. F.R.I. provides economical unit cost with reliability and quality through complete co-operation on design and engineering.

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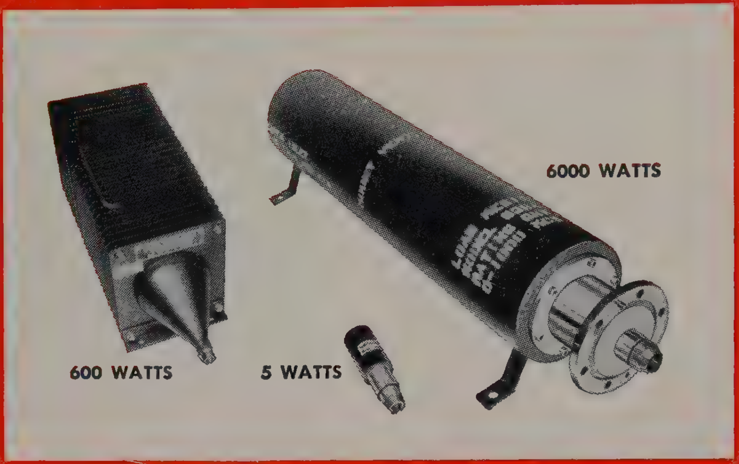
Circle Reader Service Card 63

MicroMatch®

RF LOAD RESISTORS COVER THE RANGE:

TO 6000 WATTS AND 3000 MCS.



MicroMatch RF Load Resistors provide the virtually reflectionless terminations needed for accurate RF power measurement. They serve many useful purposes as non-radiating RF power absorbers, particularly in lieu of antenna systems during the measurement and alignment phase of transmitter operation.

Other useful functions are in conjunction with feed-through wattmeters to form excellent absorption-type wattmeters, and as a load for side-band elimination filters or high power directional couplers.

SPECIFICATIONS		RF LOAD RESISTORS	
MODEL NO.	FREQUENCY RANGE (mcs)	RF POWER DISSIPATION (watts)	RF CONNECTORS
601	0-3000	5	N, C or BNC
603	0-3000	20	N, C or BNC
633	0-3000	50	N, C or HN
634	0-3000	150	N, C or HN
635	0-3000	200	N, C or HN
636	0-3000	600	N, C or HN
638	0-2000	6000	3⅛" flange

Many other special models have been designed and manufactured to meet your particular space and input connection requirements.

For more information on RF Loads, Directional Couplers, Tuners, and RF Wattmeters, write:

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M. C. JONES ELECTRONICS CO., INC.

185 N. MAIN STREET, BRISTOL, CONN.
SUBSIDIARY OF THE Bendix CORPORATION

Circle Reader Service Card 64

New Products

(Continued from page 109)

quencies of from 490 to 1000 mcs. Synchronously tuned stages are used, with planar low-noise triodes as amplifiers. The equipment is contained in a 19 inch rack mounted chassis 5 1/4 inches high by 1 inches deep. A regulated anode and heater power supply is provided.

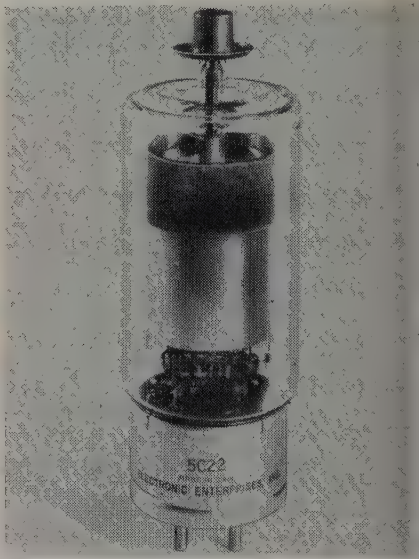
Gain of the amplifier is greater than 20 db, and noise figure is a maximum 10 db. VSWR input and output is 1.75.

The Model HFW-8(A) amplifier available with other frequency ranges bandwidths, and gain.

Circle Reader Service Card 143

—*mwj*—

ELECTRONIC ENTERPRISES ANNOUNCES NEW HYDROGEN THYRATRON TUBES



Electronic Enterprises, Inc., Newark N. J., manufacturers of gas and mercury vapor rectifiers, vacuum rectifiers, grid controlled rectifiers, triodes and hydrogen thyratrons, has announced a hydrogen thyratron tube, Type 5C22/HT415.

This tube, which is capable of producing pulse outputs in excess of 2.0 megawatts at an average power level of 1.6 kilowatts, was designed primarily as a radar pulse modulator. The new hydrogen thyratron tube features high peak voltage and high current ratings, high repetition rate, short deionization time and low time jitter.

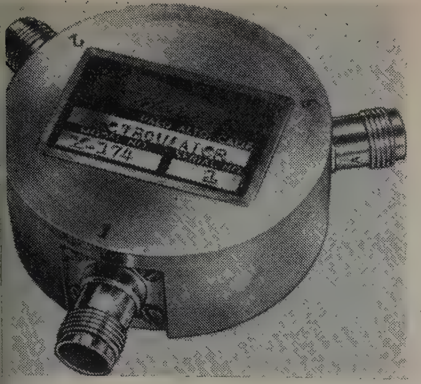
Circle Reader Service Card 144

—*mwj*—

FERRITE CIRCULATORS DESIGNED FOR TELEMETRY OPERATION

Melabs, Palo Alto, Cal., has added t its ferrite component line two "S" band circulators designed for telemetry operation. Model HS-1 covers the 2200-230 Mc frequency band and model HS-2 the 2700-2900 Mc frequency band.

The miniature units weigh 4 or ounces depending on choice of connector which are type "N" or "TNC". The physical dimensions are 2.5 inches in diamete



nd 1 inch in height. Both circulators ex- ibit an isolation of 20 db minimum and maximum insertion loss of 0.3 db. The ower handling capability is 1 watt verage. In addition the circulators are apable of operating over wide temperaure variations without degradation of heir characteristics.

Delivery is 30 to 45 days after receipt f order; price is $300.00 f.o.b., Palo lto, Cal.

Circle Reader Service Card 80

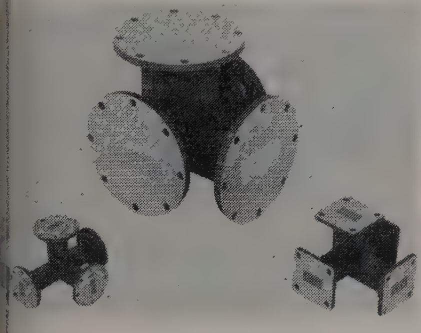
—*mwj*—

HYBRID JUNCTION TEES AVAILABLE

Waveline, Inc., Caldwell, N. J., has nnounced the availability of a complete eries of matched and unmatched Hybrid unction Tees (also known as E/H or Magic Tees). These hybrid junctions conist of a section of waveguide upon which series and shunt waveguide arm are ounted at the exact midpoint.

Special attention is given to the imortance of holding the units' mechanical olerances to extremely close limits to inure accurate alignment of the shunt and eries arms as well as their perpendicuarity to the main waveguide section.

Matched tees are equipped with apropriate iris or ramp matching devices to chieve exceptional electrical characterisics. Efficient design and accurate fabricaion techniques result in excellent reducion of VSWR values relatively wide andwidths. In addition, isolation between he shunt and series arm is greater than 5 db over the applicable frequency ange.

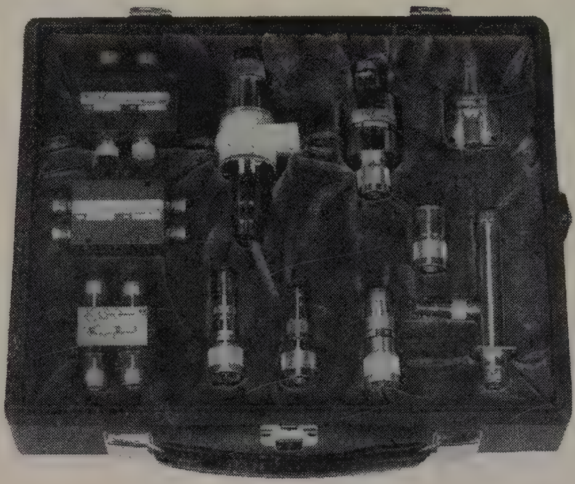


All units are constructed of silver razed brass which is silver plated and inished in instrument grey enamel and all rms are provided with standard waveuide cover flange connectors.

Circle Reader Service Card 81

—*mwj*—

"IF YOU'RE WONDERING WHAT HAPPENED TO THE SAGE HALF DOLLAR — I SWALLOWED IT."



"My engineering representative will soon be visiting you (I hope) with his new tote case full of *SAGE-LINE* production models. Some are the familiar standbys; others are new products that are receiving much attention,

To whit:

COAXIAL BALANCED MIXERS
SINGLE ENDED MIXERS

COAXIAL HYBRIDS — COBRIDS®
DC BLOCKS

COAXIAL CRYSTAL HOLDERS
WAVEGUIDE CRYSTAL HOLDERS

COAXIAL ATTENUATORS
ROTARY JOINTS

COAXIAL TERMINATIONS

SAGE LABORATORIES, INC.
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Circle Reader Service Card 75

NEW LITERATURE

GE OFFERS BULLETIN ON APPLICATION OF TRIODES

Application of Ceramic Planar Triodes — Bulletin PT-46, which provides information to assist designers in application of GL-6442 and GL-6771 disk-seal triodes, is available from General Electric Power Tube Department, Schenectady, N. Y.

Information is presented for application of the tubes as amplifiers, oscillators and multipliers. Examples of typical circuits are included as well as complete technical data on the two tubes and a discussion of the principal considerations of high-frequency cavity design.

Circle Reader Service Card 82

—*mwj*—

BULLETIN ON LUMPED-CONSTANT DELAY LINES ISSUED BY CORNELL-DUBILIER

Bulletin 192, a 12 page publication covering CDE lumped-constant delay lines, has been published by the Cornell-Dubilier Electronics Division, Federal Pacific Electric Co., Newark, N. J.

Most of Bulletin 192 is taken up with the basic design considerations in lumped-constant delay lines. Discussed in simple, yet technical, language are the following subjects: the ideal delay line, simulating the ideal, frequency response, rise time, phase shift vs. frequency, characteristic impedance, reflected delay lines, tapped delay lines, delay tolerance, design limitations, and time delay measurements.

Various charts and schematics are included on (1) a typical delay line; (2) circuit configurations; (3) effects of phase considerations; (4) reflected delay lines and (5) a test circuit for relay measurement. There is also a graph showing the ratio of delay time to rise time.

Another feature of Bulletin 192 is a series of sample calculations showing the steps in calculating tapped "straight-through" delay lines, untapped "straight-through" delay lines, and "open" reflected delay lines.

Also included are photos of typical CDE lumped-constant delay lines as well as a cutaway illustration showing their design and construction features.

Circle Reader Service Card 83

—*mwj*—

LITERATURE ON COAXIAL MICROWAVE FILTERS AVAILABLE FROM WAVELINE

A new four page illustrated brochure of coaxial microwave filters is available from Waveline, Inc., Caldwell, N. J. The literature describes ganged or individually tuned coaxial resonant cavity devices which operate over various bands of frequency covering the overall range of 2.1 to 5.9 kMc.

A detailed description explains techniques used to accomplish miniaturization, frequency stability, diplexing and mixing functions as well as special system requirements. A series of standard coaxial bandpass filters are described with technical data, and other multisection filters are illustrated.

This literature has been prepared to present the availability of standard coaxial filters as well as the many modifications and variations for special systems requirements that are readily available from Waveline, Inc.

Circle Reader Service Card 84

—*mwj*—

BROCHURE ON WIGGINS ALL-METAL BAR -X- SEAL NOW AVAILABLE

A four page condensed brochure which summarizes the engineering features of its new, all-metal Bar -X- seal has been released by Wiggins Connectors, Los Angeles, Cal.

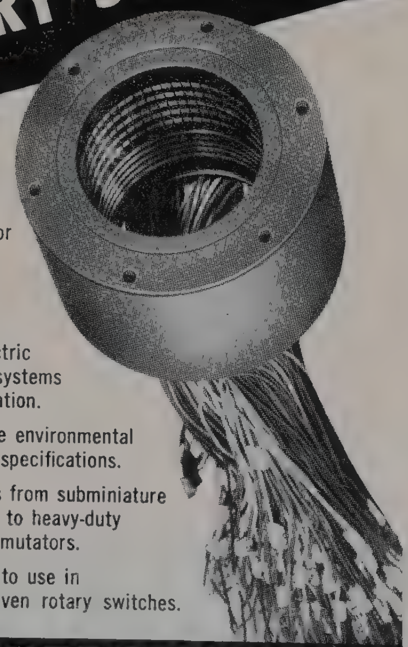
Contained in the two color brochure are diagrams illustrating the seal's engineering concept (one-piece construction with the cross section resembling an 'X') and typical Bar -X- sealing applications.

Engineering features and ordering information are also included.

Wiggins recently introduced the Bar -X- seal which seals at extreme temperatures (—450°F to +1200°F) and withstands peak pressures of 40,000 psi.

Circle Reader Service Card 85

MOTOR-DRIVEN
ROTARY SWITCHES



Special designs to meet your performance specifications for
high-speed
precise
multi-circuit
switching
in complex electric and electronic systems and instrumentation.

Built to meet severe environmental conditions and MIL specifications.

Capacities and sizes from subminiature dry-circuit selectors to heavy-duty power-handling commutators.

Write for check-list to use in specifying motor-driven rotary switches.

ELECTRO SWITCH
SLIP-RING DIVISION, CORP.
OSTERVILLE, MASSACHUSETTS

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EXCLUSIVE - THROUGH RESEARCH

MODEL D-1196
VARIABLE ATTEN.
0-500 MC
0-25 DB
RADAR DESIGN CORP.
SYRACUSE, N. Y.

CONTINUOUSLY VARIABLE
ATTENUATOR *FLAT* 0-500 MC

RDC* research has produced the only
precision line of
LT SLOTTED SECTIONS AND TERMINATIONS
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Perpetual research and development makes available to you over
1,000 SPECIAL COAXIAL DESIGNS

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C. W. TORNGREN MECATORN BROCHURE RELEASED

Advances in metal spinning with the ecatorn Powerspun process are discussed n a two color, eight page brochure from he C. W. Torngren Co., Somerville, Mass. Mecatorn is the patented, hydraulically ontrolled, semi-automatic, powerspun rocess developed by Torngren to meet he highest quality control standards. A ydraulic feedback control automatically uplicates close tolerances either for rototype development or longer producon runs. Pressures up to 200,000 psi are xerted through the hydraulic system on he Mecatorn machines enabling them to pin 5/8 inch stainless steel and nonrrous metals up to 1 1/2 inches in thickess.

Illustrated with recent developments, his brochure also features the spinning nd fabrication facilities now available C. W. Torngren for the Electronic, issile and Nuclear fields.

Circle Reader Service Card 86

—*mwj*—

HUGHES PUBLISHES HIGH VACUUM LINE SHORT-FORM LIST

A short-form catalog describing the igh vacuum equipment line of the ughes Aircraft Company's vacuum tube roducts division, Oceanside, Cal., is now vailable.

Included in the catalog are descriptions f gauge tubes and controls and ion umps.

Circle Reader Service Card 87

—*mwj*—

BULLETIN ON FUSED QUARTZ OFFERED BY DELL OPTICS

The Micro-Fused Quartz Dept. of Dell Optics Co., Ltd., West New York, N. J., is offering its Bulletin 501. This bulletin sets forth availabilities from stock of varied shapes and sizes of fused quartz for infrared, microwave and analytical applications. A chart of physical properties of clear fused quartz is also presented.

Circle Reader Service Card 88

—*mwj*—

ALUMINUM DIP-BRAZING FACILITIES BROCHURE AVAILABLE

John Gombos Co., Inc., Clifton, N. J., announces the availability of its dip-brazing facilities brochure to industry.

Aluminum Dip-Brazing is a process that allows perfect joining of aluminum to form homogeneous parts. The process permits the creation of complex configurations which were formerly impractical, difficult, or too costly to fabricate by other known methods. Aluminum Dip-Brazing offers a strength of weld equal to or better than the parent metal. When thick to thin materials are brazed, complete penetration of joints is accomplished, and distortion is at a minimum. Complex machining is eliminated, lower costs are achieved, strength of joints is maintained, and tooling requirements are reduced.

The John Gombos Co., Inc. has utilized this method in the manufacture of its wide line of microwave and electronic components, as well as special mechanical design, to custom requirements.

Circle Reader Service Card 89

—*mwj*—

Horizon House, Inc., Publisher of "the microwave journal" and "the solid state journal", is inviting interviews from persons, preferably with an engineering background, who are interested in

ADVERTISING SPACE SALES.

We are expanding our sales staff and have a territory available in the middle Atlantic area, based either in Washington, D.C., or Philadelphia, Pa.

If a different and rewarding career offers you a challenge, arrange for an interview by letter or telephone.

Replies, of course, confidential.

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GUARANTEED MICROWAVE PERFORMANCE

FILMOHM WAVEGUIDE ATTENUATOR ELEMENTS

Pre-tested, performance-proven FILMOHM Rectangular Waveguide Attenuator Elements offer high reliability through stringent quality control of dimensional and resistance characteristics. FILMOHM metal film attenuator elements can be supplied to specific attenuation and frequency spread requirements.

TYPES OF ATTENUATOR ELEMENTS AVAILABLE

FOTOCERAM*—A high precision attenuator element possessing superior shock and vibration resistance. An extremely stable, reproducible and rugged element. HIGHEST COST—Available in prototype or production quantities to specifications. **BULLETIN FCA-1.**
*T M. Corning Glass Wks., Corning, N.Y.

FILMCARD*—An easily fabricated, LOWEST COST metal film Fibreglass Resistance Card for all low power attenuators and terminations. Available in a wide range of resistance values and thicknesses. ASK ABOUT NEW FILMCARD KIT. **BULLETIN P-2.** *T.M. Appl. For

METALLIZED GLASS—Hi-precision, moderate cost standard elements available for L through K bands, attenuation up to 70 db. Furnished with metallized eyelets for solder mounting, or drilled holes. **BULLETIN A-1.**

METALLIZED MICA—**Rugged and Flexible.** For use as rotary and guillotine attenuator elements. Ideal for mm. frequencies. Available in large sheets or fabricated parts of from .001 to .005" thick. Moderate cost. **BULLETIN C-1.**

STANDARD ELEMENTS FOR ALL FREQUENCIES... OR CUSTOM ELEMENTS DESIGNED TO YOUR SPECS

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Circle Reader Service Card 67

FINANCIAL NEWS

CROSBY-TELETRONICS INAUGURATES STOCK OPTION PROGRAM FOR KEY EMPLOYEES

Crosby-Teletronics Corporation, Westbury, N. Y., has inaugurated a stock option plan for its key employees, Murray G. Crosby, president, announced.

The plan was hailed by Mr. Crosby "as the first step in a broad program to attract and retain the best scientific and administrative brains available."

He said the timing of the program was related to a recent announcement that "the company had definitely turned the corner on sales and profits" and would have total revenues exceeding $1.5 million this year.

—*mwj*—

LITTON ANNOUNCES 43% SALES INCREASE

Sales of Litton Industries for the first quarter, ending Oct. 31, totaled $52,111,000, an increase of $15,676,000 over the $36,435,000 for the same period last year, Charles B. Thornton, president and chairman of the board, told stockholders at the annual meeting.

The 43 per cent increase in sales was matched by a 40 per cent increase in net earnings which totaled approximately $2,150,000 for the quarter as compared to $1,537,000 earned in the same quarter a year ago.

Earnings per share on the 4,265,421 shares of common stock outstanding amounted to 50 cents as compared to 40 cents a year ago. Thornton said the figures on per share earnings for the first quarter last year have been adjusted for the 2 for 1 stock split of December 1959 and the 2½ per cent stock dividend of October, 1960.

—*mwj*—

INDIANA GENERAL THIRD QUARTER RESULTS POINT TO RECORD SALES YEAR

Indiana General Corporation's 1960 sales will show a slight increase over 1959's record amount, according to Robert F. Smith, president. At the end of the third quarter, sales totaled $14,948,502, as compared to the $14,762,855 recorded at this time last year.

Although the profit picture improved during the past three months, Mr. Smith felt doubtful that it would equal the previous year's record of $1,552,449.

Mr. Smith stated that, "Generally speaking, we have found neither great optimism nor pessimism expressed for the immediate months ahead, but rather a feeling that business will continue at a reasonably good level." He indicated that in several areas, customers are having to hold back on their purchases because of conditions within their own markets.

All divisions and the Canadian subsidiary operated profitably during the nine months period.

—*mwj*—

Engineers
MICROWAVE TUBE
B. S. to Ph. D.

If your interests are related to...

- multielement phased array amplifiers
- lightweight low noise amplifiers for broad band receivers?
- low drainage satellite communication tubes
- high-powered periodically focused traveling-wave amplifiers,

then investigate immediately the select opportunities currently existing at the Hughes Microwave Tube Division in Southern California. You'll find responsibility limited only by capability in this stimulating atmosphere.

For immediate consideration, write or call collect: Mr. Don MacDowell, ORchard 0-1515, Extension 5792.

HUGHES

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MICROWAVE TUBE DIVISION
11105 ANZA, LOS ANGELES 45
CALIFORNIA

IMMEDIATE OPENINGS FOR:

ANTENNA SECTION HEAD

Restricted stock option available

Antenna design and development covering the spectrum from 8 KC to 40 KMC. Broad Band Antennas, Hi Gain Antennas, Countermeasure Systems.

MICROWAVE SECTION HEAD

Restricted stock option available

Advanced Microwave Component Design and Development in the Fields of Solid State Devices, Band Pass and Diplexing Filters, High Speed RF Switches, Crystal Video Detectors, Parametric Amplifiers, etc.

To arrange interview with Dr. L. Riebman, President call Mr. J. W. Cox, Personnel Administrator for appointment at WAlnut 5-8780 (Phila., Pa. call collect)

AMERICAN ELECTRONIC LABS., INC.

121 North 7th Street, Philadelphia 6, Pa.

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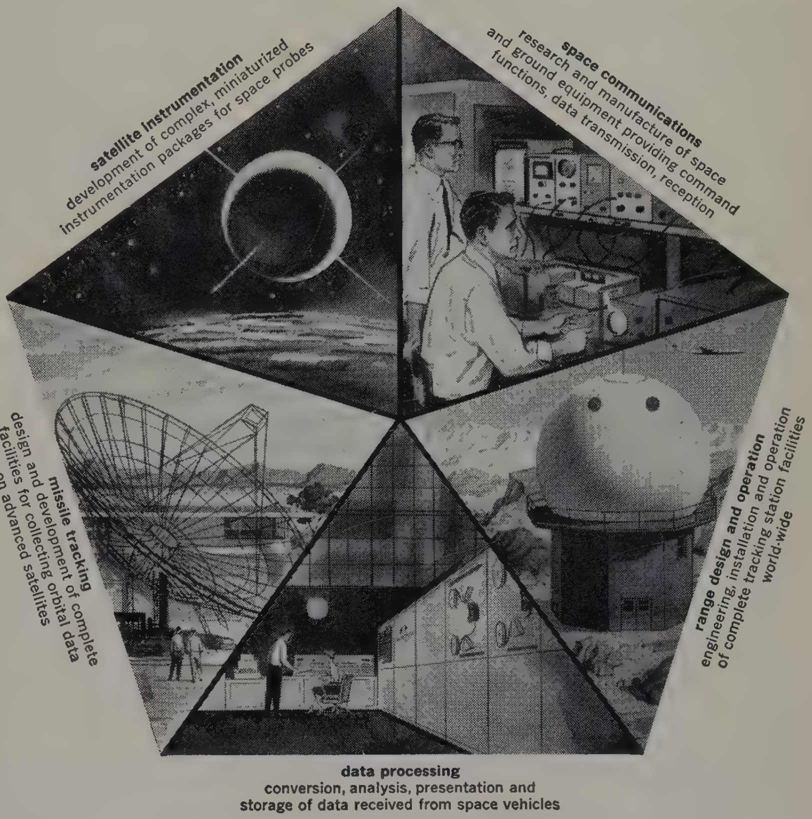

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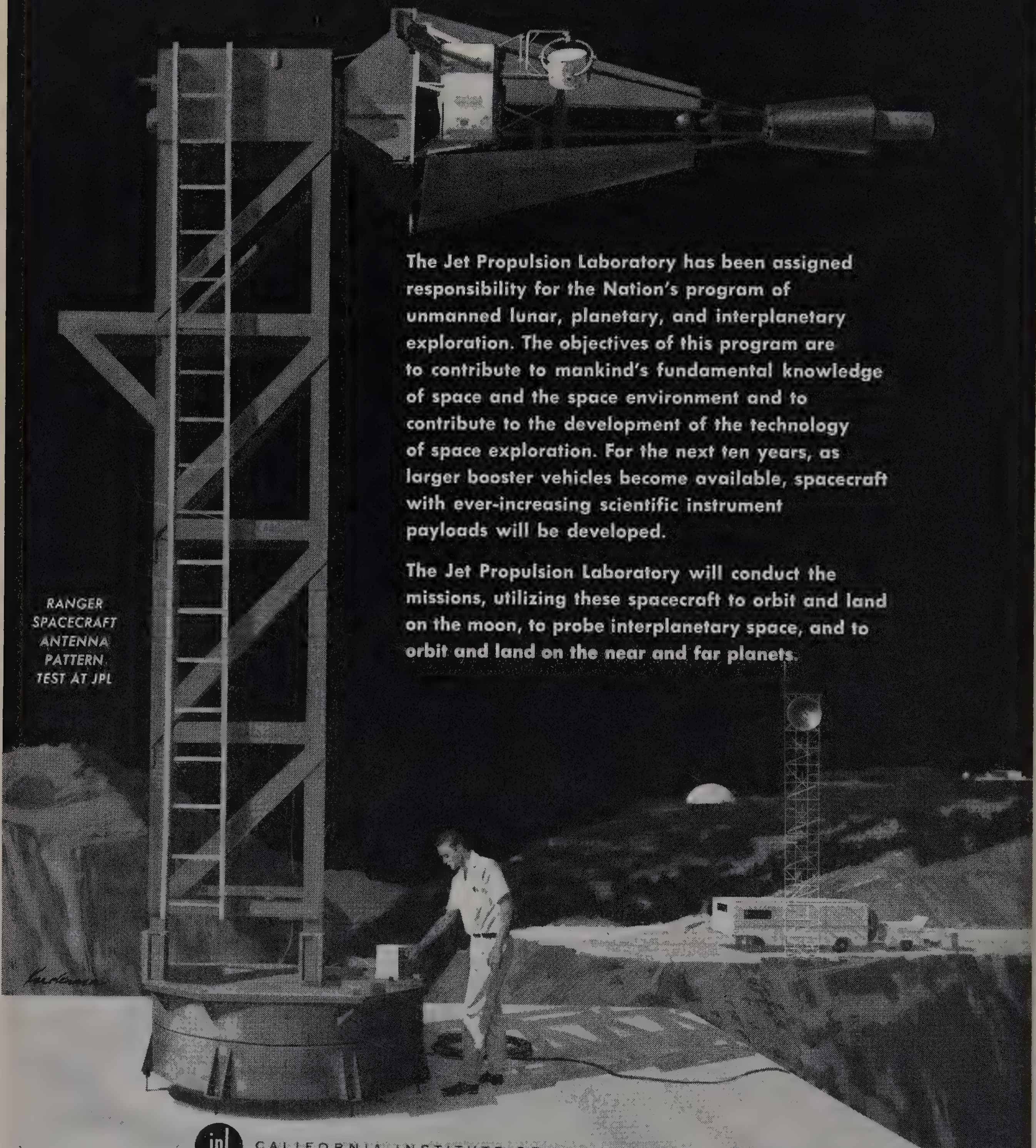

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The SHORT WAVE in the LONG RUN

"HOW MANY . . . NEW COMPANIES . . . WILL FALL BY THE WAYSIDE?"

ROBERT KRAUSZ
PRESIDENT, RANTEC CORPORATION
Calabasas • California

The microwave segment of the electronics industry n recent years has accounted for the formation and frequently the successful growth of many new enterprises. The factors that have caused and will continue to encourage new companies are not well defined. Some were started to satisfy the personal ambitions, desires and goals of their founders. It should also be recognized that much of the phenomenal growth in the birth rate of microwave companies is attributable to the favorable business environment that has enabled a relatively high percentage of these new companies to survive the difficult formative years as against the much higher mortality rate in other industries. In order to judge future industry trends, it would be appropriate to examine various facets of our industry to see what changes may occur and their effects.

The prime factor responsible for the many new ventures into the microwave industry has been the rapidly ncreasing market for its products. Also, it is quite certain that a large part of the future microwave market will consist of products not yet developed. This combination of an expanding market and a rapidly advancing technology presents the most favorable climate for the growth of the typical microwave company. A contrary condition may prevail in a market such as baby carriages which, although growing rapidly due to a rising birth rate, will not foster the creation of many new companies. The existing manufacturers can easily expand their output with present know-how and facilities. It is doubtful that new baby carriage designs or improved manufacturing methods would stimulate the entry of many new companies in that industry.

The microwave industry has an important advantage in the marketing of its products. The customer contact is generally a highly skilled person who is able to evaluate the product because of his technical qualifications and ability to use the test facilities which are available to him. This is not the case in an industry which markets a consumer product where the buyer normally is unable to properly evaluate its merits. The sale of those consumer items commonly found in the home or for personal use, and even many designed for commercial application, depends largely on the establishment of brand names and public acceptance of the manufacturer. This process is usually too costly and time consuming to be undertaken by a new company. Those organizations of long standing and well known to the public naturally benefit from the expanding market for this type of product.

As opposed to this sales promotional requirement, consider the small newly established microwave company which produces a higher quality or more useful item. Even though it is advantageous for such a company to enjoy recognition by the technical users of its products, still if they are relatively unknown they may develop appreciable sales volume because the buyer can properly evaluate the technical performance.

A further factor which has been instrumental in the creation of new microwave enterprises has been the fairly low initial capital requirement as compared to the many industries which require much expensive machinery and large size facilities. The initial financing of a new microwave company has been easier to obtain due to the predicted growth of the industry and the aura of glamour

---

ROBERT KRAUSZ was educated at Ohio State University where he received his BEE in 1947. He was a Research Associate with the Ohio State University Research Foundation Antenna Laboratory and a Research Specialist with Aerophysics Laboratory at North American Aviation.

In 1951 he was one of the principals founding the Microwave Engineering Company and served as Vice President and Chief Engineer until 1953. At that time the staff and facilities of the Microwave Engineering Company were acquired by Stanford Research Institute, and he remained as Manager of the Southern California Laboratory's Engineering Division which specialized in research and development of radio frequency systems and components.

Mr. Krausz became President of Rantec Corp. in 1956 and presently serves in this capacity. He has been active as Chairman of the Professional Group on Antennas and Propagation and as the Professional Group Coordinator and Vice Chairman of the Los Angeles Section.

surrounding it. Much could be said about the type of financing best suited for the long pull. Many times, a public stock offering has provided the means for raising capital. Unfortunately, at times, the amounts involved have not been in keeping with the true value of the company either present or future. It is hoped that the inevitable losses sustained by those unsophisticated investors influenced by such practice will not cause an adverse reaction and tend to undervalue the stocks of the successful companies.

A further advantage enjoyed by a new and technically competent microwave company is the ability to obtain support for development programs. This ability arises partly because such a company can have low operating costs during its formative years, and also because it is able to employ senior people in the preparation of the proposal and subsequent performance of the work. In larger companies, it frequently becomes necessary that personnel of similar high caliber have to devote a large portion of time to supervisory responsibility of much larger groups of people than perhaps the total employment of the small company.

Due to the specialized product of the microwave industry, it is frequently possible to concentrate sales efforts among only a few potential customers who are the most likely users. Frequently, the new company, although quite successful as far as early growth is concerned, obtains a large percentage of its sales volume from relatively few buyers. When this company performs well it may continue to receive the major portion of similar subcontracting from those same customers. However, to negotiate sales of similar products with additional buyers may require excessive sales effort to displace the current suppliers.

The fact should not be understated that one of the most important assets of a small company in the microwave industry is its technical staff. There is no doubt that this industry is principally a "brains" business since the technology is changing so rapidly. It can generally be found that new companies are formed with a strong nucleus of scientists and engineers which can provide the original customer contact as well as product know-how. Generally, this group is motivated both by their desire to succeed as well as their financial interest in the company. As the company matures and becomes financially successful, these initial incentives gradually diminish in import.

One further factor favorable to a small operation is the ability to move rapidly. The nature of present requirements, especially in the military fields, generally lead to "crash" programs where delivery is of the utmost importance. It is much easier for a small, well-integrated operation, to accomplish contract negotiations together with development and fabrication in a minimum of time.

When one considers the various advantages offered to a small and relatively new company in this industry, it becomes apparent why an estimated three new companies a week are being formed. The question which has been asked by numerous publications and at many management meetings poses the problem of long-term success for these companies. How many will have to consolidate with larger operations, and how many will fall by the wayside? One can point to the automobile industry, where it is found that of the original several hundred companies formed while the industry was young, only five have survived. Notably, there have been relatively few advances in technology within the automobile industry. The fatalities in the microwave industry will certainly not be as drastic because several of the favorable factors indicated previously do not apply to the automobile industry.

Items produced by mass production techniques tend to favor the large established organizations, financially able to maintain the necessary equipment and facilities. Furthermore, the sale and distribution of such products involve large expenditures to establish brand names and instill confidence in the companies' financial resources. The microwave industry is sufficiently different in several aspects from these mass production industries so that we can hopefully say that their high rate of dissolution is not necessarily applicable to our industry. However, as the products of the microwave industry receive wider acceptance and are used in systems which are sold in large quantities, production facilities, proper advertising and the general corporate acceptance by the customer will become increasingly important. As competition for the markets of existing products increases, only those companies which have new and unique products or services to offer will be able to successfully enter the field.

Recent declines in the stock market, especially of so-called "glamour" stocks which have been highly overvalued by some standards, also may indicate that it will become more difficult to obtain financing under terms as favorable as during the last few years. This may again tend to favor established, well-financed operations and will no doubt slow the rate of creation of new companies.

In the discussion above, no consideration has been made with respect to the continuing growth of the market. Several publications for the military microwave market have been quite optimistic and have indicated an overall growth of the market of nearly 30 per cent per year. It is doubtful whether such a growth rate can be maintained for more than, perhaps, five years. Even though no definite figures are available, it seems that more new enterprises are being formed than even this high rate of growth can support. Competition will become increasingly keen and the success of a new operation may be more difficult to achieve in the years to come.

This increasing competition becomes evident when it is observed how many proposals are prepared in the microwave industry. As the number of bidders for each job increases, the percentage of success for each company has to decrease. Those companies with insufficient present resources and profit margins will not be able to stand the burden of proposal costs. Some differentiation, of course, must be made between component manufacturers, which have "off-the-shelf" products, when compared to companies who manufacture subsystems or develop items to the customer's specifications. Component companies, once they have developed a good product line, have been able to compete more successfully in present day markets and it is anticipated that this trend will continue. Foreign competition in certain product areas, however, will continue to garner a greater share of the market.

The development of a product line, of course, takes

(Continued on page 122)

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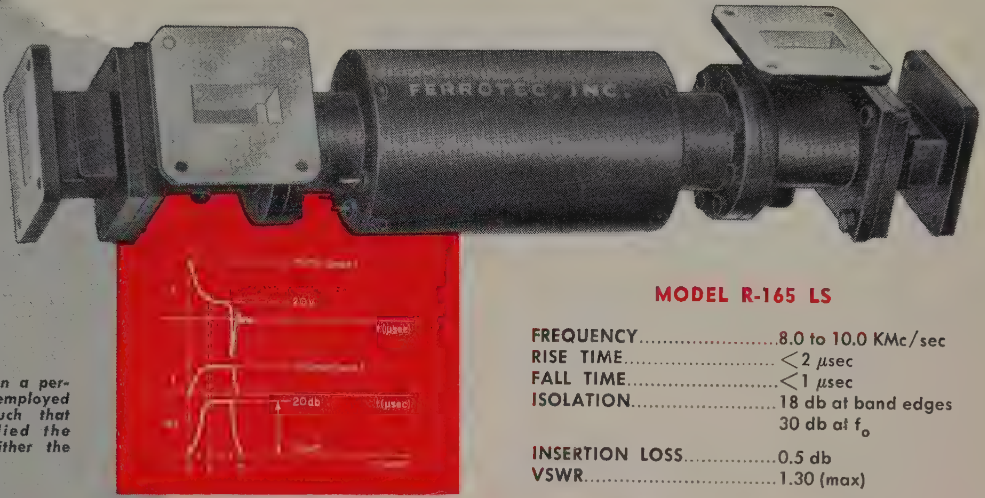
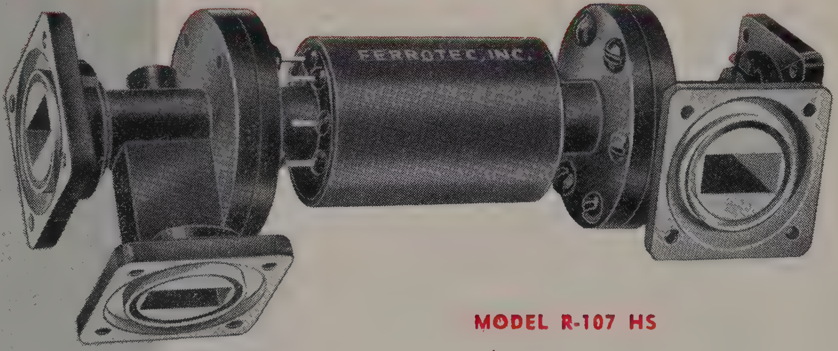


MODEL R-165 LS

FREQUENCY	8.0 to 10.0 KMc/sec
RISE TIME	<2 μsec
FALL TIME	<1 μsec
ISOLATION	18 db at band edges 30 db at f_o
INSERTION LOSS	0.5 db
VSWR	1.30 (max)

Model R-107 HS K_u band high power fast ferrite switch permits two microwave antennas to be time-shared by a common transmitter and receiver.



MODEL R-107 HS

FREQUENCY	15.7 to 16.9 KMc/s (any 2% band)
ISOLATION	Trans-Rec, 20 db (min) Ant-Trans, 20 db (min)
INSERTION LOSS	Trans-Ant, 0.5 db (max) Ant-Rec, 0.5 db (max)
VSWR	1.20 (max)

LENGTH	5.5 inches
POWER	100 KW (peak), 100 watts (average)
WAVEGUIDE	Mates RG-91/U
FLANGES	Mates UG-541/U
	90% switched
SWITCHING TIME	10 μsec (max)
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MODEL T-150 L

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INSERTION LOSS	0.5 db
VSWR	1.20 (max)
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HEIGHT	2.1 inches
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KRAUSZ

(Continued from page 120)

considerable time as well as company funds. At times, there is a great temptation for a new company to develop a product line closely akin to items familiar to their technical personnel from previous employment. One can read of lawsuits against new companies, initiated by the former employer of personnel in these companies. In several instances, courts have ruled that new operations may have to be careful how they handle their dealings with customers familiar to them from previous employ, or the sale of products closely related to products familiar to them in their former employment. The whole question of proprietary rights and ethics within the industry will no doubt receive increasing attention. So far, the ground rules to follow have been ill defined, but it may become more difficult in the future for a group of engineers to start a business based on products and customers substantially the same as those of their former employers.

It is quite likely that in the years to come the sma and the new in the industry will be beset by many problems which may stem from insufficient capital, compet tion from larger and longer established companies, lac of management experience or the vicissitudes of gover ment procurements. However, as long as the microwav industry continues to strive for technological advanc ment, these companies that can create the environmen to germinate new ideas, and convert these ideas quickl and efficiently into products and programs will fin success.

It is hoped that the microwave industry may continu to provide opportunity to those who, through thei creative efforts and recognized technical capabilities, ca provide the nucleus of a new company and thereby increase the total capability of a young industry.

A NOTE TO INDUSTRY MANUFACTURERS

The Microwave Engineers' Handbook

The publishers of *the microwave journal* invite your participation in the microwave handbook and catalogue now being prepared for publication.

We are presently collecting charts, nomographs, graphs, tables, etc., all devoted to microwaves which will be a great service to our readers. It has been demonstrated that the microwave engineer is either inadequately served or his field of interest is handled as a small part of the entire electronics field.

We are now in the process of collecting and editing as much useful information as possible, which pertains specifically to microwaves including VHF, UHF and millimeter waves. Many manufacturers have compiled useful data which have been promised for this handbook. In addition to the technical information, we expect to have a complete microwave directory of manufacturers and products.

It is planned that the microwave handbook and catalogue will be published on an annual basis beginning with our first edition in the summer of 1961. With each succeeding year, we will revise, expand, and improve the handbook section.

Your careful attention to our questionnaire will be of great value in the preparation of this industry directory. This questionnaire, certainly, will benefit you, the manufacturer, in that your firm and its products will be effectively presented to the industry through the pages of "the microwave engineers' handbook and buyers' guide."

If you did not receive this questionnaire, please contact the editors, "the microwave engineers' handbook," 1330 Beacon Street, Brookline 46, Mass. The questionnaire was mailed in December from Horizon House, Inc.

Theodore S. Saad

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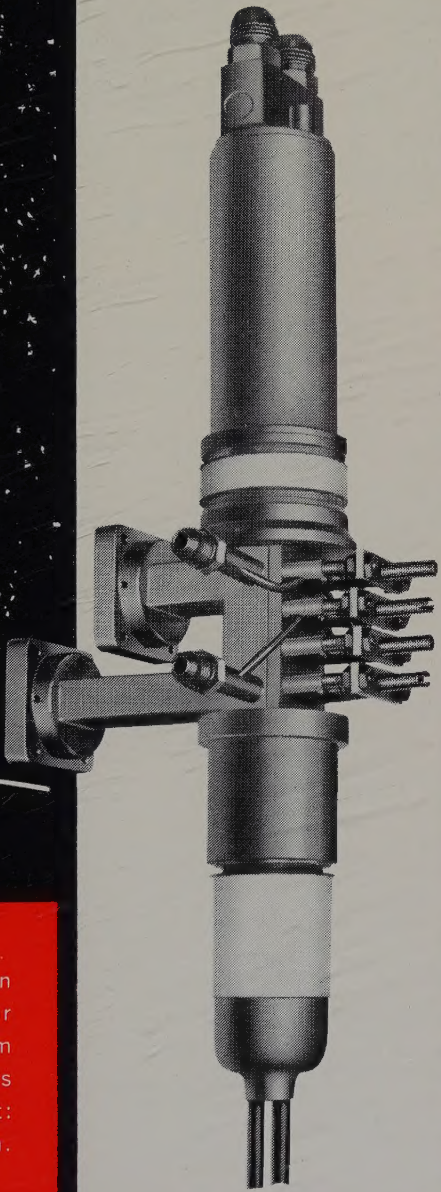
33	34	35	36	37	38	39	40	105	106	107	108	109	110	111	112
41	42	43	44	45	46	47	48	113	114	115	116	117	118	119	120
49	50	51	52	53	54	55	56	121	122	123	124	125	126	127	128
57	58	59	60	61	62	63	64	129	130	131	132	133	134	135	136
65	66	67	68	69	70	71	72	137	138	139	140	141	142	143	144

COVERS
- ☐ FXR, Inc.
- ☐ Varian
- ☐ Raytheon

INSERTS
- ☐ Polarad

for space systems

20kW CW at X-band



Varian's new VA-849 amplifier klystrons are rated to deliver higher CW power at X-band than any existing tube in the world . . . 20kW!

Varian's new VA-849 power klystron opens up a variety of new design approaches to space systems. Possible applications exist in communication concepts such as repeater satellites, moon-bounce signalling, or in reflections from clouds of tiny orbiting needles. Radio astronomers, too, will welcome the VA-849.

Immediate applications include CW radar and illuminator service. Low incidental noise. Water cooling. Electromagnet focusing. Another significant advance in microwave components from Varian's broad experience and research in super-power tubes.

FEATURES

- **7.125 to 8.5 kMc**
- **20 kW CW**
- **50 db Gain.**
- **30 Mc Minimum Bandwidth**
- **Tunable 60 Mc.**

It's likely that Varian can provide a solution for your particular system design problem. There's a good way to find out: write Tube Division.

VARIAN associates

PALO ALTO 34, CALIFORNIA

BOMAC LABORATORIES, INC.
VARIAN ASSOCIATES OF CANADA, LTD.
S-F-D LABORATORIES, INC.
SEMICON ASSOCIATES, INC.
SEMICON OF CALIFORNIA, INC.
VARIAN A.G. (SWITZERLAND)

RECENT RAYTHEON DEVELOPMENTS
IN MICROWAVE FERRITE DEVICES

RAYTHEON
MODEL CUL40
SERIAL NO. 6655
RAYTHEON
MODEL CLL40
SERIAL NO.
4444
RAYTHEON
MODEL CSL40
SERIAL NO.
5566

CUL Series for UHF

CSL Series for S-band

CLL Series for L-band

New miniature broadband circulators for UHF, L & S bands

Now, Raytheon introduces compact, lightweight, three-port circulators with extremely low insertion losses

Miniaturized Raytheon coaxial line circulators for UHF, L- and S-bands now are available with isolations of 20 db and insertion losses of .5 db and less!

The L- and S-band units—in production just 14 months after Raytheon announced the first coaxial ferrite circulator to the microwave industry—can be mounted directly to steel structural members without any separation or shielding. Maximum dimensions are 1¾ inches for S-band, 4 inches for L-band and 6⅛ inches for UHF models. A combination of any two of the units can be packaged for a highly efficient 4-port circulator.

To learn more about these significant developments and other circulators now available down to 400 Mc and up to 6000 Mc with similar characteristics, please write, stating your particular area of interest, to the following address: Raytheon Company, Special Microwave Device Operations, Waltham Industrial Park, Waltham 54, Massachusetts. In Canada, contact Raytheon Canada Limited, Waterloo, Ontario.

TYPICAL SPECIFICATIONS OF MINIATURIZED CIRCULATORS

	UHF BAND CUL SERIES	L-BAND CLL SERIES		S-BAND CSL SERIES
Frequency Range	800-1000 Mc	1000-1700 Mc	1700-2400 Mc	2400-4000 Mc
Bandwidth	Any 10% band	Any 10% band	Any 10% band	Any 10% band
Isolation	20 db min. 35 db max.	20 db min. 35 db max.	20 db min. 35 db max.	20 db min. 35 db max.
Insertion Loss	0.3 db min. 0.5 db max.	0.2 db min. 0.4 db max.	0.2 db min. 0.4 db max.	0.2 db min. 0.4 db max.
VSWR	1.25 max.	1.25 max.	1.25 max.	1.25 max.
Power (Average)	5 watts	5 watts	5 watts	5 watts
Power (peak)	5 kw[2]	5 kw[2]	5 kw	5 kw
Weight (max.)	4.8 lbs.	3.3 lbs.	2.3 lbs.	11 oz.
Diameter (max.)[1]	6⅛ in.	2½ in.	2½ in.	1¾ in.
Height	3¼ in.	4 in.	2½ in.	1⅝ in.
Connectors	Type N	Type N	Type N	Type N
Temperature Range[3]	T_0 ±20°C	T_0 ±20°C	−40°C to +60°C	−40°C to +60°C

[1] Excluding Connectors

[2] Up to 100 kw is possible with Type HN connectors

[3] T_0 is 25°C unless otherwise requested

RAYTHEON

RAYTHEON COMPANY
SPECIAL MICROWAVE DEVICE OPERATIONS